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Field Artillery Notes
No. 8

see p. 66

From the latest information obtained from American Field Artillery Schools in France and other European sources.

Edited at the
ARMY WAR COLLEGE
WASHINGTON, D. C.
January, 1918

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JAN 1918		**00-00-1918 to 00-00-1918**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Field Artillery Notes. No. 8	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army War College,Carlisle,PA,17013**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**68**	

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WAR DEPARTMENT,

WASHINGTON, *January* 30, 1918.

The following "Field Artillery Notes" are published for the information of all concerned.

[A. G. O., No. 062.1.]

BY ORDER OF THE SECRETARY OF WAR:

JOHN BIDDLE,

Major General, Acting Chief of Staff.

OFFICIAL:

H. P. McCAIN,

The Adjutant General.

FIELD ARTILLERY NOTES NO. 8.

CONTENTS.

1.

NOTES ON

THE TERRAIN BOARD.

Indoor Firing Practice.

The object of this instruction is the training of officers in the conduct of fire without the expenditure of ammunition. This instruction should be given concurrently with the study of volume 3, Field Artillery Drill Regulations, 1916, and other authorized instructions on the conduct of fire. It should be understood by the instructor that terrain board instruction is valuable in proportion to the number of problems which officers fire in that instruction and that lengthy critiques by the instructor waste time.

The material required is as follows:

(*a*) A blackboard.

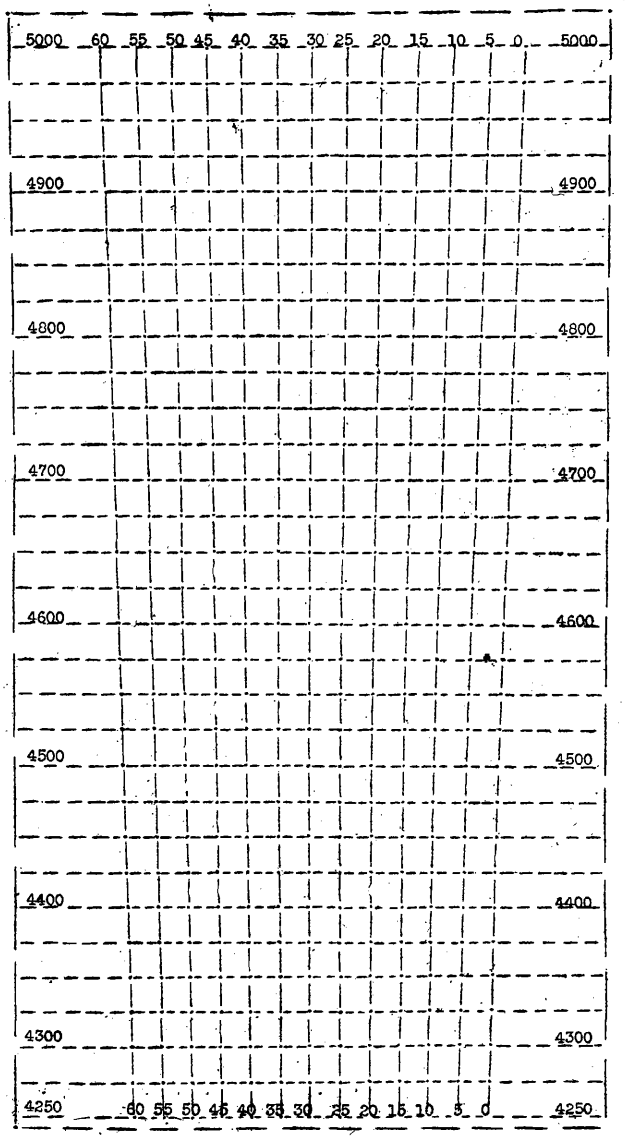
(*b*) A terrain board and its appurtenances.

The details of this material are as follows:

(*a*) The blackboard should be a large one and should have represented on it in white paint a horizontal line above which appear four equally spaced rectangles representing the four gun sections of a hostile battery.

(*b*) The terrain board and its appurtenances should be as follows: First a table about 5 feet by 3 feet. This table should be ruled on a scale of 1 to 500 between ranges 4,250 and 5,000, by lines perpendicular to the plane of fire, these lines being 25 meters apar to scale and parallel to the short dimension of the table. Every 100 meters should be numbered. These lines are intersected almost at right angles by lines 5 mils apart radiating from the supposed position of the gun as a center. Each one of these lines is numbered. (See illustration on page 6.)

For the purpose of representing heights of burst there are used pieces of copper wire, straight except where bent at a desired point of the length into a circle containing a white disc. In this way bursts 1, 2, 3, 4, 5, 6 mils and higher bursts, if desired, may be accurately represented, as well as percussion bursts, the last being black.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Direction of Fire

In addition targets are cut to scale out of pasteboard or other suitable material to represent buildings, trees, clumps of woods, trenches, exposed batteries, wire entanglements, intersections of trenches, observatories, machine-gun emplacements and other objectives. To represent the dispersion, in range, direction or height of burst, slips of cardboard placed in a box or other container may be advantageously used at times, especially in the simulation of bursts in fire for accuracy and in fire with lateral observation where dispersion in range shows up. The numbers on these cardboard discs are arranged to follow the law of probabilities.

For general use these discs should show the factor by which the probable error should be multiplied to represent the dispersion of a shot in any one of its forms of variance, as in deflection, height of burst, or range. Also there must be a complete set marked + and a complete set marked —. Thus, for the set of discs marked +, 25 should be between 0 and 1, 16 discs should be between 1 and 2, 7 discs should be between 2 and 3, and 2 discs should be between 3 and 4. The set marked minus should have an equal quantity of discs with numbers corresponding exactly to the numbers shown on the discs marked plus. The above discs are most appropriate for use in instruction of officers of regiments of 155. For regiments of 75, however, there should be 25 discs marked + and 25 discs marked —. On the discs marked +, the following numbers should appear 0, 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 16, 17, 19, 20, 22, 25, 27, 28, 30, 35, 40, 45, and 52. The same numbers should appear on the discs marked —. This arrangement is based on the approximate probable error of 15 meters at the ranges shown on the terrain board.

A box of either of the above kinds of discs is used as follows: The student gives commands appropriate to the firing of a battery salvo. An assistant to the instructor takes at random 4 discs from the box. The instructor determines what would be the center of impact of each gun for the elevation announced in the command, and in representing the actual points of burst, applies from each center of impact an offset of a value and sign as represented by the disc appropriate to the shot. In most cases the only dispersion worth considering is dispersion in range.

If it is desired by the instructor at any time to represent the form of terrain, this representation may be accomplished by placing on the table an unfolded O. D. blanket or by piling on it heaps of sand or sawdust, but when this is done the exact representation of bursts is somewhat more difficult.

The terrain board is set up at one side of the room, sufficiently illuminated. At the desired distance to scale and at the desired direction is seated the Battery Commander. It is supposed that the gun is always in prolongation of the axial line of the table and at an actual distance of 8.05 meters. The instructor takes his place at the terrain board and announces the problem. The B. C. performs or assumes the necessary computation of firing data and gives all of the commands required for opening fire. At the command "fire" the instructor places the discs for such bursts as he determines are visible, requiring the B. C. to sense them aloud. The B. C. observes points of bursts and gives the commands appropriate for the next fire. In indicating bursts in time fire, it must be remembered that distance along the direction of line of fire will be seen by the B. C. in perspective and that, in placing the bursts, it is only necessary to place them in front or in rear of the target and at the proper height, without attempting to indicate to scale the amount over or short. In indicating the bursts of percussion fire, especially where the terrain is represented by sand or sawdust, the point of burst should be placed as exactly as possible.

The placing of bursts in direction is always done accurately by the instructor utilizing the lines on the table numbered in mils. The representation of mean height of burst of a salvo is also accomplished with accuracy by the careful selection and use of simulated heights of burst. In this connection the instructor must make a proper use of the proportion of bursts shown on graze.

Order of the Instruction.

In order to afford a sound basis to each officer for his knowledge of the principles of fire, the instruction should be given at first in the most elementary way, first using a blackboard and representing a single target below which appears a horizontal scale of mils. Each officer in turn should be required to give a command appropriate for placing on the line of the target a single shot shown incorrect for deflection. (Right 10 or left 5, etc.) These and all subsequent exercises should be repeated many times for each officer. Later a platoon salvo should be shown fired at a platoon target. In this platoon salvo the directing piece should be correct for deflection and the other shot should show an error in deflection difference. Each officer in turn is required to give a command appropriate for correcting the deflection difference. (Open 5 or close 10, etc.) The next phase of the instruction should again be accomplished by representing a target appropriate for a platoon and showing a salvo in which

the directing piece is incorrect for deflection and in which the deflection difference is incorrect. Each officer in turn is required to give a command appropriate for correcting the deflection and distribution (Right 10, Close 5, etc.) Next, the personnel under instruction should be given a side view of the trajectory and each officer should be made to understand that in time fire a change of corrector alone moves the burst along the curve of the trajectory, a change of range alone moves the burst along the line between the gun and the former point of burst, a change of site alone moves the burst virtually in a vertical plane through the former point of burst. Next, the personnel under instruction should be required to give commands for firing a battery salvo and to change the mean height of burst by appropriate commands so as to obtain the proper height for adjustment. In this instruction deflection, deflection difference and range are assumed correct. Next, the instructor should assume a deflection, deflection difference and corrector adjusted and require officers to obtain stated brackets on a given target. When officers have learned how to handle separately all the elements of fire, then and not until then should they be required to fire problems of simulated fire, involving the simultaneous adjustment of all the elements. The instructor is then ready to use the terrain board and begin with simple problems in direct observation, passes from them to lateral observation, to fires of accuracy and to fires for effect on various targets.

During this terrain board work he must interject instruction in the use of the firing tables ("Tables de Tir"), including the determination of the Corrections of the Moment and, if topographical material is at hand, in computing initial firing data from the map. In conclusion, the instructor must thoroughly understand the value of instruction is measured not by the number of lectures given to the personnel under instruction but by requiring personnel to actually prepare and conduct simulated fire. The value of instruction varies directly with the number of problems properly completed per officer under instruction.

TYPE TERRAIN BOARD PROBLEMS.

(A) For Officers of 75 Regiments.

1st Problem.

Axial observation: Adjustment with time shrapnel. The instructor indicates as target a hedge, width 40 mils, and requires the B. C. to obtain a 100-meter bracket. Preparation assumed not

accurate. Deflection incorrect by 40 mils, distribution 75 mils too wide; height of burst 5 mils high. Correct range 2,900.

B. C. announces his initial data with range 2,600.

The instructor indicates four high bursts, the right one being 40 mils to the right of the target, the sheaf too wide.

The B. C. senses H? H? H? H? and commands down 5, 2,800.

Instructor relieves B. C. and details another officer to take his place. The B. C. should have adjusted his sheaf.

New B. C. commands: Left 40, close 25, 2,800.

Instructor indicates —L —G —L —G.

B. C. commands 3,000.

Instructor indicates +L +G +L +G.

B. C. commands 2,900.

Instructor indicates —L +G —L +G.

B. C. commands 2,900.

Instructor indicates +G —L +I —G.

Instructor commands "Suspend Firing." At this point the B. C. has his first piece on the proper part of its target. He commands to his executive "Lay parallel on 1st piece." The battery is now ready to open on any target by an appropriate shift from basic deflection.

2d Problem.

A problem in lateral observation where a range change of 400 meters involves an apparent displacement of the point of burst of about 40 mils. The instructor turns the table to satisfy this condition, the axial line of the table pointing at the assumed position of the gun. The instructor indicates as target a trench intersection. The instructor assumes the correct range to be 4,550 and initial direction to be 25 mils to left of line gun—target.

B. C. commands: Basic deflection right 60, site —5, corrector 18, battery right, 4,500.

The instructor indicates on the table four shots which the B. C. observes left of the line observer—target.

B. C. announces 4,900.

Instructor indicates the shots which B. C. observes, sensing the shot from No. 2 gun on the line O. T. and direction over.

B. C. commands: 2d piece, 2 rounds, right 40, 4,500 and senses direction short.

B. C. commands: Left 20, 4,700 and senses direction over.

B. C. commands: Right 10, 4,600 and senses direction over.

B. C. commands: Left 5, 4,550 and senses direction bracketing.

Instructor directs: Suspend firing.

In the above problem the instructor might well utilize the box of probable errors, leaving nothing to his imagination in plotting the points of fall.

3d Problem.

Fire for accuracy with the quadrant, model 1888, to register a fire of offensive counter preparation on a hostile first-line trench. The instructor assumes the gun range to be 4,585 or a quadrant range of 8° 59′ using normal charge, white fuse. The value of 100 meters is here about 22′.

B. C. commands: 1st piece, normal shell, white fuse, two rounds, quadrant 9° 2′.

Instructor indicates over.

B. C. commands 8° 18′.

Instructor indicates short.

B. C. commands 8° 40′.

Instructor indicates short.

B. C. commands 8° 51′.

Instructor indicates short.

B. C. now has a bracket 8° 51′—9° 2′, or 11′, which is about 50 meters.

B. C. commands: 6 rounds, 8° 56′.

Instructor uses his box of probable errors and plots shots. This results in two overs and four shorts. The B. C. must increase his elevation by as many times one probable error as he wants shots to change sides to get an equal number of shorts and overs. One probable error equals 4′.

B. C. commands 8° 60′.

Instructor plots shots, using box of probable errors, which results in 3 shorts and 3 overs.

Instructor commands: Suspend firing.

4th Problem.

The fourth problem involves fire for effect on a battery whose guns are seen, after an advance by our forces. This problem illustrates application of fire for effect.

Instructor indicates 3 guns seen on edge of a wood, personnel partly exposed.

B. C. commands: Basic deflection, left 100, open 10, site 0, corrector 18, battery right, 3,000.

Instructor indicates short with air bursts below.

B. C. commands: Up 2, 3,400.

Instructor indicates over.

B. C. commands: 3,200.

Instructor indicates over.

B. C. commands: Up 2, battery 3 rounds sweeping, 3,200, 3,100, 3,000, 3,050, 3,150, 3,200, 3,100, 3,000.

Instructor states that battery has ceased firing and indicates a fourth gun now visible.

B. C. commands: Left 5, close 5, normal shell, black fuse, battery right 3,200.

Instructor indicates short.

B. C. commands: 3,400.

Instructor indicates over.

B. C. commands: 3,300.

Instructor indicates short.

B. C. commands: Battery 5 rounds, sweep by 1 turn 3,300, 3,325, 3,350, 3,375 (sensed over) 3,375, 3,350, 3,325, 3,300 (sensed short)—2d, 3d, 4th piece, 1 round a minute 3,325, 3,350: 1st piece at my command. 1st piece left 3, 4 rounds 3,325 (O. S. S. S.) 3,350 (O. S. O. S.). Right 1, 3,350 (O. S. S. O.) 3,350 (O. O. O. O.) 3,350 (S. O. O. O.) 3,325 (O. S. O. S.) 3,325 (S. O. Target—Target).

1st piece suspend firing. 2d piece at my command, left 3, 4 rounds, 3,325.

Instructor commands: Suspend firing.

Examples for Terrain Board Exercises for 155-mm. Howitzer.

1. *Axial Observation: Ranging with One Gun.*

Instructor indicates: Adjust your battery by piece on this target (target indicated on terrain board). Preparation not accurate; bracket 20.

B. C. commands: Battery attention, azimuth from Y line 4,600; shell O. A. fuse S. R. Charge 2; site +5; No. 1 only, others follow; elevation 482.

Instructor indicates, —.

B. C. commands 522.

Instructor indicates L 5, ?

B. C. commands R5, 522.

Instructor indicates +.

B. C. commands 502.

Instructor indicates +.

B. C. commands 482.

Instructor relieves B. C. and details another officer to take his place. The B. C. should have verified his 502 before changing.

New B. C. commands 502.

Instructor indicates +.

B. C. commands 482.

Instructor indicates +.

B. C. commands, 2 rounds, 482.

Instructor indicates — —.

B. C. commands, 3 rounds, 492.

Instructor indicates — + +.

B. C. commands 492.

Instructor indicates — + +.

B. C. commands: No. 1 suspend firing, elevation 489. Mark elevation and deflection.

2. *Lateral Observation: Adjusting by Piece.*

Instructor indicates a target on terrain board. Preparation accurate, bracket 20, 1 mil in deflection corresponds to 2 twentieths in elevation. Observer to right of battery.

Note.—In this problem rights and lefts of line observer—target are indicated + and −.

B. C. commands: Battery attention; azimuth from Y line 3,560; shell F. A. fuse I; charge 1; site —3; No. 1 only; elevation 500.

Instructor indicates —.

B. C. commands 520.

Instructor indicates —.

B. C. commands 540.

Instructor indicates +.

B. C. commands 530.

Instructor relieves B. C. and details another in his place. B. C. made mistake of splitting his bracket before verifying both limits.

New B. C. commands 540.

Instructor indicates +.

B. C. commands 520.

Instructor indicates —.

B. C. commands 530.

Instructor indicates direction, —.

B. C. commands left 10, 550.

Instructor indicates —.

B. C. commands 570.

Instructor indicates +.

B. C. commands 570.
Instructor indicates +.
B. C. commands 550.
Instructor indicates +.
B. C. commands 550.
Instructor indicates direction, +.
B. C. commands right 5, 540.
Instructor indicates +.
B. C. commands 520.
Instructor indicates —.
B. C. commands 520.
Instructor indicates —.
B. C. commands 540.
Instructor indicates direction, +.
B. C. commands right 3, 534.
Instructor indicates direction, —.
B. C. commands 534.
Instructor indicates —.
B. C. commands 534.
Instructor indicates direction, +.
B. C. commands 3 rounds, 534.
Instructor indicates + — +.
B. C. commands 534.
Instructor indicates — — +.

B. C. commands suspend firing, elevation 534; mark elevation and deflection.

3. *Bi-lateral Observation.*

The instructor indicates the target.—Target—observation post. Adjust one gun, carrying your adjustment through 12 rounds for effect. Your preparation is not accurate.

Assumption by instructor.—There will be an error of 15 mils in the deflection. Correct elevation will be 562, using O. A. Shell, C. R. fuse, charge 2.

B. C. commands: Battery attention, Y azimuth 3,862, O. A. shell, S. R. fuse, charge 2, site +6, No. 1 only, elevation 540.

Instructor indicates:
Right observer —40.
Left observer —10.

B. C. commands: Right 15, elevation 600.

Instructor indicates:
Right observer +60.
Left observer +44.

B. C. commands: Left 8, elevation 570.

Instructor calls on another officer to act as B. C. (The command should have been Left 8, 2 rounds, 570, since 570 would be either over or short, and would have to be immediately verified.)

B. C. commands: Left 8, 2 rounds, elevation 570.

Instructor indicates:

Right observer +10 and +16.

Left observer +6 and +8.

B. C. commands: Right 3, 1 round, elevation 540.

Instructor indicates:

Right observer —30.

Left observer —31.

B. C. commands: 3 rounds, elevation 555.

Instructor indicates:

Right observer +8, —4, and —5.

Left observer +7, —5, and —7.

B. C. commands: Elevation the same.

Instructor indicates:

Right observer —2, +4, and —10.

Left observer —3, +5, and —12.

B. C. commands: C. R. fuse, 6 rounds, elevation 560.

Instructor indicates:

Right observer +4, —2, —10, target, —8, and +10.

Left observer +5, —1, —9, target, —9, and +9.

B. C. commands: Elevation the same.

Instructor indicates:

Right observer —12, —4, +3, —14, +6, and —7.

Left observer —13, —3, +1, —13, +5, and —7.

B. C. commands: Suspend firing.

B. C. then states he would fire 24 rounds for effect at elevation 562 or 563.

4. *Flank Observation: Ranging by Platoon.*

Instructor indicates target, observer to right of battery, preparation accurate, bracket 10.

Note.—In this problem rights and lefts of line observer—target are indicated + and —.

B. C. commands: Battery attention, aiming point church steeple in ————. Deflection No. 1, 895. Lay for parallel fire. Shell O. A., fuse C. R. charge 1, site —5, right—right, elevation 360.

Instructor indicates + +.

B. C. commands 350.
Instructor indicates — +.
B. C. commands No. 1, 350; No. 2, 340.
Instructor indicates — —.
B. C. commands No. 1, 360; No. 2, 340.
Instructor indicates + —.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates direction — —.
B. C. commands No. 1, left 10, 355; No. 2, 350.
Instructor indicates +; direction +.
B. C. commands, No. 1, 355; No. 2, right 10, 350.
Instructor indicates, No. 1, direction +; No. 2, direction —.
B. C. commands, No. 1, right 5, 355; No. 2, left 5, 350.
Instructor indicates — +.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates, direction —; direction +.
B. C. commands, No. 1, left 3, 355; No. 2, right 3, 350.
Instructor indicates + +.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates direction — —.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates, direction —; direction +.
B. C. commands, No. 1, left 1, 355; No. 2, 350.
Instructor indicates —; direction —.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates + —.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates, direction +; direction —.
B. C. commands, No. 1, 355; No. 2, 350.
Instructor indicates — —.
B. C. commands: Suspend firing, No. 1, 355; No. 2, 349. Mark elevation and deflection.

II

NOTES ON

CALCULATION OF FIRING DATA.

1. Summary of steps which are to be taken by a Battery Commander as soon as a target for his battery has been designated.

Steps	Orders
1. Decide upon the method of fire.	
a–Projectile.	Such a projectile (F).
b–Fuse.	Fuse for shell chosen.
c–Charge.	Charge.
(Be sure the fuse is the correct one for the charge chosen).	Prepare so many rounds.
2. Determine:	
A *a*—Deflection (D).	Left (or right) by.
A *b*—Distribution (DD).	Open (or close) by.
A *c*—Drift.	
A *d*—The effect of lateral wind.	
B I—The angle of site.	Angle of site.
B II—The complement angle of site.	
B III—The effect of longitudinal wind.	
B IV—The effect of variation of weight of projectiles.	(Method of fire).
B V—The effect of the density of the air.	
B VI—The effect of the temperature on Vo. (*i. e.*, on the initial velocity).	
B VII—The elevation (of the howitzer).	
3. Record the bracket.	Elevation.

The above "steps" are to be calculated by using the information recorded in the Range Tables and from the reports rendered at certain intervals by the meteorological office.

Every officer should be familiar with the types of projectiles and fuses in order that he can quickly decide which type of each is to be used.

Initial deflection and range are obtained from the map or from the plotted position of the gun and target on the firing chart, or sometimes (the unusual case) when the B. C. can see his guns, by using the aiming circle alone. External conditions affecting them have to be taken into consideration and appropriate corrections made before fire is opened. There may be, of course, certain occasions upon which a B. C. will not have sufficient time to calculate all the corrections. However, he must decide which corrections are to be calculated, due consideration being given to the circumstances of the case and to the time available for calculations.

Necessity for Corrections.

External causes affecting the accuracy of fire may alter the gun range by three or four hundred meters, hence during actual hostilities it is most important to accurately prepare for firing.

On account of the large number of batteries in a limited area, a B. C. will only be able to locate bursts which are near his target. In addition, ranging will be more rapid and easier when the deflection is good. This is a very important factor in trench warfare where conditions are such that long telephone connections are very often required. If ranging with aerial observation, the observer will land, after two and a half, or at the most three hours in the air, and if the time taken for ranging has been very long he will not be able to observe the fire for effect.

When shifting the fire from one target to another it is important to have the preparation accurate.

Causes Affecting the Fire.

1. *The temperature of the ammunition* affects the initial velocity.
2. *The air density* affects the movement of the projectile.
3. *The weight of the projectile* affects the initial velocity and the effect of the air resistance.
4. *The wind* affects both the direction and the range.

Variation of Initial Velocity.

The "Initial Velocity" depends on, first, the lot of powder; second, the gun; third, the weight and temperature of the ammunition. As one does not know the variations due to the lot of powder and the gun, it is necessary to determine them by actual ranging, but the other variations may be calculated and the corrections made before firing.

Atmospheric Corrections.

(*a*) *Temperature.*—The variation of the initial velocity is calculated by the formula:

$$d\mathrm{Vo} = 0.001\ (t - 15)\mathrm{Vo}.$$

15 = Normal temperature.
dVo = Variation of initial velocity.
t = Temperature of ammunition dump.
Vo = Range Table initial velocity.

However, this formula is not very accurate, for at the moment of firing the temperature of the ammunition is not known. Moreover

the effect of temperature on different lots of powder is not necessarily the same. When ranging, the bore is not warm enough to warm the charge and, if required precautions have been taken (sheltering charges from the sun, avoiding loading the gun beforehand), the above formula may be used, t being the temperature of the ammunition dump. Table VI, in the Range Tables, gives the variation in range due to a variation of muzzle velocity of 10 meters per second, or $d\text{Vo} = 10$ m.

(*b*) *Weight of Projectile.*—The range table has been compiled for projectiles, the mean weights of which are:

Elongated steel shell, 43 kilograms,
Cast steel shell, 43.75 kilograms,
Shrapnel, 40.59 kilograms,

but a range correction has to be calculated, using the mean weight of the *lot* of projectiles being used.

Table VI in the "Range Tables" give for the various projectiles, charges, and ranges the *variation of range* corresponding to a one-tenth of a kilogram variation of weight.

Variation of weight of the projectile alters the initial velocity and the effect of the air resistance, the range therefore being increased or diminished.

(*c*) *Air Density.*—The meteorological office issues reports of the temperature and pressure of the air at a given altitude. The *pressure decreases by* 9 *milograms each* 100 *meters increase of altitude*, hence the pressure at the altitude of the battery can be easily determined.

Temperature and pressure being known, the chart between pages 15 and 16 (Range Tables) enables one to determine the air density, and Table VI (Range Tables) gives the correction to be made.

The elevation of the piece is to be increased when the density increases.

(*d*) *Wind.*—The reports from the meteorological office come in the following form:

Groups of six figures, the first two indicating the altitude of the wind considered, the second two its direction, and the third two its velocity in meters per second. For instance: 15 04 06, means that the wind considered is at an elevation of 1,500 meters, its direction is 4 and its velocity is 6 meters per second.

The direction of the wind is given with reference to a circle divided into forty equal parts in a clockwise direction, with the zero, or forty, pointing towards the *geographic north.* The wind blows from

the circumference of the circle toward the center. For instance, a 15 wind is a southeast wind.

To counteract the effects of wind it is necessary to know its components on the line of fire and a line perpendicular thereto. These may be found from the chart between pages 15 and 16 of the Range Tables, or by means of a graduated circle, the diameter of which is 20 centimeters and the center of which is the battery, drawn and graduated on the map.

The direction and velocity of the wind change with the altitude and one should calculate the effect of the wind on the whole trajectory. However, this is not done and the *direction and velocity to be used are those of a wind at four-fifths the maximum ordinate given in the range table for the topographic range.*

Note 1.—The meteorological office sometimes sends the "Ballistic Wind," in which case the altitude of a wind corresponding to the maximum ordinate is taken without reduction. Whether the wind is the "real" or "ballistic" wind is always stated in the meteorological report.

Example:

Ballistic Wind,
15 14 06

means that the wind which is to be *employed for correcting* a range, the corresponding maximum ordinate of which is 1,500 meters, has a direction of 14 and a velocity of 6 meters per second.

Note 2.—A slide rule and plotter have been constructed to calculate the above corrections, but their use is not always convenient and their exactness is not, practically, greater than that of the range tables.

Ranging Coefficient.

In trench warfare, as it now exists on the French front, it is very often necessary to fire several different times on the same target, for example, retaliation fire, barrage fire, counter preparation fire, etc., one must be able to open fire on these targets as soon as called for and without ranging. This will be possible if the results of the previous ranging on each target are stripped of the effect of external causes and brought down to the values they would have had if firing had been carried out under the same conditions at which the range tables were compiled, that is, with air density of 1.208 and a zero wind.

The method of calculating the above is as follows:

Let

R = Topographical range.

Cs = Correction corresponding to the variation of the mean weight of the projectiles from the mean weight of the projectiles used in the Range Table calculations.

Cd = Correction corresponding to the variation of air density.

Cw = Correction corresponding to the longitudinal wind.

CVo = Variations due to other causes.

R^1 = Range resulting from the actual ranging.

$R_1 = R + Cs + Cd + Cw + CVo$.

But the correction CVo consists of two factors, the first resulting from the effect of the actual temperature on the charge (this may be calculated and corrected) and the second resulting from the actual temperature *at the very moment* the gun is fired, from the lot of powder, from the difference between the mean weight of the projectile and the actual weight, from the gun, etc. These components of the second factor are not known by the organization commander. Therefore CVo may be represented by the formula $CVo = Cvo' + CVo''$.

If we strip from the range R_1 all corrections which have been made in order to determine the initial range we have,

$$R_1 = R + Cs + Cd + Cw + CVo = R + Cs + Cd + Cw + CVo' + CVo''.$$

If R^1 represents the stripped range,

$$R^1 = R_1 - (Cs + Cd + Cw + CVo'),$$

but $$CVo' = CVo - Cvo'',$$

therefore $$R^1 = R_1 - Cs - Cd - Cw - CVo + CVo'',$$

but $$R = R_1 - Cs - Cd - Cw - CVo,$$

therefore $$R^1 = R + CVo''$$

and the ranging coefficient Ko which is,

$$\frac{R^1}{R} = 1 + \frac{CVo''}{R},$$

will remain unchanged when firing the same lot of powder and projectiles, at about the same range and may characterize the lot of powder under these conditions.

From the results of ranging we deduce:

(*a*) The stripped direction.

(*b*) The stripped range.

(*c*) The ranging coefficient.

If we are later to again fire on the same target, one determines the data by altering the stripped direction and range by the conditions actually existing at that later time.

Shifting the Fire.

Suppose we are to fire on a target the topographical range of which is R_2 and the sum of the calculated conditions being represented by M. The adjusted elevation would be

$$R_2+M+CVo''$$

or

$$R_2\left(1+\frac{CVo''}{R_2}\right)+M.$$

If R_2 and R are not perceptibly different

$$R_2(1+CVo'')+M=KoR_2+M,$$

K*o* being known from previous firing.

The required conditions to get the range by shifting the fire are:

$$\frac{3}{4} \text{ is less than } \frac{R_2}{R} \text{ is less than } \frac{4}{3}.$$

(angular distance less than 300 mils)

Note 1.—K*o* is only to be deduced after ranging which includes at least a "Fire for Improvement" of 12 rounds.

Experimental Results.

From a series of practices held by a group of heavy artillery (11th Army) the following was deduced:

1. The stripped range may change from one day to another, on the same target, but the differences are perceptibly less than one probable range error.

2. The ranging coefficient, for a different target, which realizes the required conditions, to be fired on by shifting the fire, is constant.

The following principles, therefore, may be deduced:

(*a*) If a target has been ranged on it is unnecessary to employ "trial fire," when the target is again fired on, by shifting the fire from another target. The calculated elevation is to be verified and "fire for improvement" is carried out.

Verifying an elevation consists in firing two rounds at that elevation. If they have opposite senses the elevation is taken as a *temporary elevation;* if not, the elevation is altered by *a bracket,* in the appropriate sense to carry on the "trial fire."

(*b*) When fire has to be employed without the rounds being observed the ranging coefficient enables one to start immediately "sweeping fire" by increasing and decreasing the calculated elevation by *half a bracket,* to be certain to hit the target.

(*c*) When atmospheric conditions change, during the fire for effect, corrections are to be made again, according to the new information, then the elevation is verified and fire for improvement carried out, with the new data, before resuming the fire for effect.

(*d*) The "daily range" means nothing except when external conditions remain unchanged. The "actual range" only remains unchanged.

As proof of the accuracy attained by the French in using the above method, one need only quote General von Bulow's report (Gen. von Bulow was commanding the First German Army) at the battle of the Somme. He says ". . . moreover, our enemy seems to have, for firing by the map, principles which are better and more accurate than our own, and under conditions which were absolutely unlike those of previous days, they succeed in hitting limited targets with a great accuracy."

Fire for Adjustment.

Closeness of adjustment depends on the type of fire for effect which is used and, therefore, on the kind of target. It is the B. C.'s duty to know the methods of fire for effect which are to be employed against all types of targets, and, therefore, to know the method of fire for effect he will employ before he starts the fire for adjustment.

The following rules of fire have been deduced from the experiences of several years. Every artillery officer must know them and never swerve from them, for though it may be his intention to lessen the duration of "fire for adjustment" the result will be that he only succeeds in wasting ammunition.

I. To Get the Proper Deflection.

Adjustment is to be carried out for each gun. The corrections are equal to the value of the observed errors. If an error is 1 or 2 mils, it is to be corrected only after several rounds show that it is necessary.

The B. C. should try to get, *as soon as possible, rounds in the direction of the target,* in order to know the sense of the rounds. Deflection is corrected during both the "fire for improvement," and "fire for effect."

II. To Find the Elevation.

Rounds will give information about the range if the deflection is correct. An accurate knowledge of the ground in the neighborhood of the target sometimes affords information, even though the deflec-

tion is not quite correct, but the B. C. must be very careful about accepting this information.

Trial Fire.

1. *Fire one round at the initial elevation, then increase or decrease that elevation by a "bracket," until you have two elevations bracketing the target, i.e., a "short" and an "over" elevation.*

If the firing data has not been calculated, using the fire chart, the elevation is to be increased or decreased by "*two brackets*," but the distance between the two elevations must be reduced at least to "*one bracket.*" A like method is employed when the first round is *surely* very far from the target.

2. *Verify the elevations bracketing the target.*

To do this fire one round more at the elevation which is to be verified. If that round and the one previously fired have the same sense *that sense* is assigned to the elevation. If one round was short and the other over, one gets a "*contradiction.*" To "clear" the "contradiction" fire two more rounds at the same elevation. If both rounds have the same sense take their sense as the sense of that elevation. If the senses are opposite the elevation is taken as "bracketing" and it will be the *temporary elevation* (see "fire for improvement"). A "hit" gives rise to a verification like a contradiction.

Fire for Improvement.

1. *Calculate the "temporary elevation"* (which is the average of the elevations bracketing the target, or else the bracketing elevation).

2. *Fire at the "temporary elevation" until six rounds have been observed, then increase or decrease the elevation by as many SIXTHS OF THE BRACKET (given in Range Tables, opposite each range), IN TWENTIETHS as the shorts or overs are in* excess of one-half short and one-half over.

A hit is considered as of the same sense as the rounds which are in the minority.

Exception.—When the first three rounds have the same sense, change immediately the elevation by *half a bracket* and fire three more rounds. The series of rounds is observed as if fired at the *mean elevation.*

When the last three rounds have the same sense as the first ranging, it is to be resumed.

Note 1.—"Fire for improvement" may be executed by "3-round volleys." An inexperienced observer is inclined to make such obser-

vations as "a little over or short" and to consider it unnecessary to verify the other limit of the bracket. Such observations should be energetically checked as it may lead to lengthening the time of the ranging process.

Fire for Effect.

Every gun fires a series of twelve rounds and the elevations are corrected in the appropriate sense by as many twelfths of the *Range Table Bracket, in twentieths*, as the "shorts" or "overs" exceed one-half short and one-half over.

During "fire for effect" it is advisable to observe, from time to time, series of twelve rounds from each gun, suspending, if necessary, the firing of the other guns, and, to correct its elevation, to counteract the effect of heating of the bore caused by firing.

When external conditions, or the lot of the ammunition become charged during the fire for effect, the elevation must be *verified. To verify an elevation* fire two rounds. If they have opposite senses that elevation is to be used as a temporary elevation; if they have the same sense proceed with "trial fire" by altering the elevation by *half a bracket.*

Special Precautions Which Are to be Taken when Firing on a Target Close to Our Trenches.

It must be remembered that fragments of steel shells may be thrown back as far as 600 meters from the point of burst, therefore troops occupying our trenches must be sheltered. Also it is important to remember that shells can burst as far as six probable errors on the near side of the mean point.

The following precautions are to be taken:

1. Troops are to be withdrawn from trenches which are less than *six theoretical, probable range, errors* away from the target.

2. All precautions must be taken in order that the dispersion will not be increased (sorting of lots of ammunition, taking account of varying atmospheric conditions, etc.).

When Firing.—(*a*) Range each gun separately.

(*b*) Begin at an elevation which will surely give overs, then draw nearer the target by prudently decreasing the range by small quantities (practically, a quarter of the distance between the target and our lines).

III.

NOTES ON

METHODS EMPLOYED IN RANGING WITH THE 155-MM. HOWITZER.

In the Range Tables for the 155-mm. howitzers, opposite each range in hundreds of meters, will be found the corresponding *elevation* in twentieths of a degree. As the sight drum is graduated in twentieths of a degree instead of meters, the elevation corresponding to the calculated range in meters is sent to the battery instead of the *calculated range in meters*.

In the fourth column of the table is what is called the "bracket" in degrees and minutes corresponding to each elevation. These brackets are the elevation changes necessary to change the point of burst at the elevation considered a distance equal to four practical probable range errors or six theoretical probable range errors. It is upon the principle of the value of the probable error at each range that the French base their ranging methods with this howitzer.

As the brackets are given in degrees and minutes it is necessary to calculate the brackets in twentieths of a degree in order to be able to quickly send elevation changes to the battery for the gunners to set on their elevation scales. To do this one simply divides the number of minutes in a bracket by three. The meaning of the words "elevation" and "bracket", being understood, their use in this lecture on ranging will be clear.

The firing may be classified under two general headings: first, fire for adjustment; second, fire for effect.

Fire for adjustment is classified as:

1. Trial fire.
2. Fire for improvement.

Trial fire and *fire for improvement* are separate and distinct parts of the fire for adjustment.

The expert battery commander is able to adjust all four guns of his battery at the same time. This requires considerable ability in handling individual corrections for each gun, without slowing up the fire of the other guns and absolute adherence to the principles of *trial fire* and *fire for improvement*, is of the utmost importance.

In order that the methods employed may be more easily under-

stood we will consider that the adjustment is being made with one gun. That, however, must not be considered the normal proceedure.

Trial Fire.

First Case:

First round—Sense, Short.

Increase the elevation by 1 bracket and fire again.

Second round—Sense, Over.

Repeat that elevation, the term used is "Prove" that elevation, which is the "over" limit of your bracket.

Third round—Sense, Over.

Decrease elevation by one bracket—to "prove" your "short" elevation or the "short" limit of your bracket.

4th round—Sense, Short.

This completes the trial fire. It having been found that the target is bracketed between the elevation which gave two shorts and the elevation which gave two overs.

Fire for Improvement.

Having bracketed the target during the "trial fire" it is now necessary to discover, as nearly as possible, the elevation which will place the mean point of impact of the rounds to the target before "firing for effect" is started.

To do this, a series of six rounds is fired at an elevation which is midway between that elevation which gave two *shorts* and that which gave two *overs*. For reasons, which will appear later on, the six rounds are fired in volleys of three rounds each.

Suppose that one three-round volley is fired and sensed two "shorts" and one "over" then another three-round volley is fired and one "short" and two "overs" sensed. It is quite evident that this elevation (which gives three "shorts" and three "overs") is *probably* the one which places the mean point of impact at the target, and "fire for effect" is started, at this elevation. However, it must not be thought that the adjustment is entirely completed when "fire for effect" is opened. The individual correction of each piece is kept up at all times otherwise the effect may be *good for one piece and not for any of the others.*

We will now consider another result which may occur during "trial fire," and carry the ranging through the "fire for improvement."

The first round is sensed as "short." The elevation is increased

by a "bracket" and another "short" is sensed. Either of two conditions or both may have caused this result, that is, assuming the gun has been properly layed:

1. The preparation of firing data may have been faulty and the elevation given too small.

2. The shot may have been one of those occasional ones, which the theory of probabilities applied to this method of ranging, shows will happen 1.8 times in 100 rounds.

3. Both conditions may exist.

However, the first condition is one which must be carefully avoided, errors in calculating data being often very costly to our own troops which we may be supporting with a barrage fire. If it had been impossible to accurately measure the range to the target or to make necessary temperature, wind, atmospheric pressure and weight of projectile corrections, another method of "trial fire" ranging would have to be used. This method will be explained later.

If the shot was "short" on account of the second condition the firing later on will prove this.

To return to our example, we have:

First elevation—short.

Second elevation—short.

Increase the elevation by a bracket and suppose an *over* sensing is now made. Fire again at this elevation. The shot is sensed *over* thus *proving* the over limit. Reduce the elevation by one bracket to *prove* the short limit.

Suppose this time another *over* is sensed. That elevation having given one *short* and one *over* is, as far as those two shots are concerned, a bracketing elevation and what is known as a "contradiction" has occurred at the elevation.

It is now necessary to "clear" the "contradiction," *i. e.*, to prove whether or not the elevation giving the contradiction is a bracketing elevation.

Fire a two-round volley at that elevation. This time suppose that both rounds are *short*. The elevation is evidently *short* for three out of four shots are short.

Start "fire for improvement" at the elevation half way between the "short" and "over" elevations or, in other words, increase the "short" elevation by one-half the bracket and fire the first three-round volley as "fire for improvement."

Suppose the first three rounds were sensed shorts. That elevation is probably a "short" elevation and the second three rounds are not

fired. The elevation is increased by half a bracket and three rounds are fired. Let us suppose they are over. We now have three "*overs*" at this elevation and three "*shorts*" at an elevation one-half bracket less. It can be proved that these shots may be considered as having been fired at the mean of the two elevations and that "fire for effect" can be started at this mean elevation, which actually is one-quarter of a bracket less than the *over* and *greater* than the short elevation.

Suppose the first three shots of the volley in the "fire for improvement" had been *over*. Applying the same principle as in the last example the elevation is reduced *half* a bracket and three rounds are fired at that elevation.

In this case "fire for effect" would be started at an elevation one-fourth of a bracket greater than that at which the last three-round volley was fired.

Let us now consider a case in which during "trial fire" a *short* is sensed; the elevation is increased one bracket and an *over* is sensed, followed by a *short;* thereby causing a "contradiction." Following the principle of "clearing" the "contradiction" a volley of two rounds is fired and both are sensed *short.* This elevation is considered a *short* elevation and the "*trial fire*" is continued according to the principles already mentioned.

Another case which may arise is:

"Trial fire" has been completed and "fire for improvement" begun. The first three-round volley gives one short, two overs. The second three-round volley gives the same result. It is evident that the mean point of burst of the six rounds is over the target and it can be shown that it is one-sixth of a bracket over the target. Hence for "fire for effect" the elevation will have to be reduced one-sixth of a bracket.

The *general rule* covering all cases of "fire for improvement" is, change the elevation at which "fire for improvement" was executed, or was considered to be executed, by as many one-sixths of a bracket as the rounds whose sense (short or over) predominate, differ from three. "Fire for effect" is then opened at this elevation.

When it has not been possible to accurately measure the range to the target, or to calculate the external causes affecting the flight of the projectile, the elevation, after the first shot of trial fire, is changed by two brackets in the appropriate way until two shots of opposite sense are observed. The elevation is then changed by one bracket and "trial fire" is carried out in the usual manner.

Fire for Effect.

In "fire for effect" twelve rounds are fired at the elevation which has been determined as the proper elevation for "fire for effect" to be started. Series of six rounds each are fired at the elevation, changed by as many twelfths of a bracket as the rounds, whose sense are in the majority, differ from six.

IV.

NOTES ON

FIRE FOR ADJUSTMENT.

1. Principles of Observation.

1. Observers can only sense what they see. They must never try to guess the respective positions of burst and target. This applies especially to lateral observation. For instance, the only sensing observer "A" can get from burst 1 (Fig. 1) is: The burst is 2 mils to the right of the line Observer—Target. He must *not* say: "I am to the left of the battery—I see the burst to the right of the target—therefore the range is short." (A round bursting in 2 (Fig. 1), seen exactly in the same direction by the observer, may correspond to a range "over.")

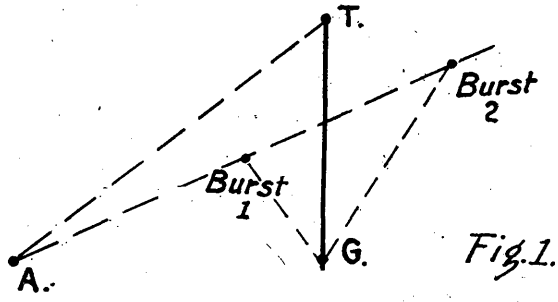


Fig. 1.

In frontal observation "guessing" comes in when the observer estimates his burst to be "just a little way" short or over and does not make the next change as great as he ought to. He has no means of estimating this distance between burst and target, and consequently this practice usually leads only to loss of time.

2. But this being admitted, all guessing being *absolutely* forbidden, the utmost must be made out of the sensing. For instance (Fig. 2) observer "A," placed to the left of his gun, sees a round bursting at 1. The smoke hides the target, he knows that, for the battery, it is "left and short." Or, observer "A" has seen one or more rounds hitting the target. The deflection has not been changed, and he

sees round 2 (Fig. 3). He *knows* that this round is on the line Gun—Target (because deflection has not been changed and probable errors in deflection are very small). He *knows*, therefore, that the round is short.

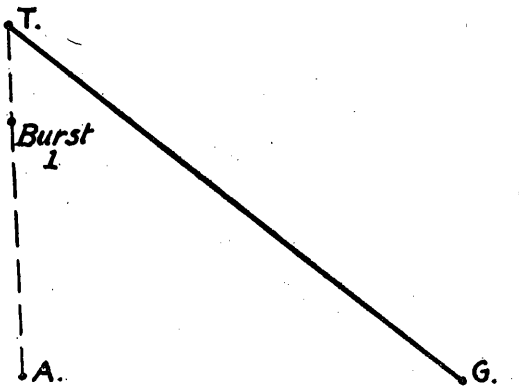


Fig. 2.

3. What you want to determine by ranging is the respective positions of target and *point of fall* of your shell and shrapnel. This holds true even in the case of time-fuzed shrapnel, because the middle of the zone of spread of your bullets is very nearly the same as the point where your burst would have occupied on percussion. It is, therefore, the latter point (and not the point of burst) which you want to bring on the target. For instance, take a burst 10 meters in front of the target and 3 mils high, at 4,000. All the effect will be over (Fig. 4). It is the point of fall and not the burst which you must bring on or near the target. Therefore, never sense "short" on a high burst, even if the smoke hides the top of the target. Whereas a high burst *seen* over is a sure over, a high burst seen short may quite well correspond to an "over" range (Fig. 5). The only case where you may be entitled to sense a high burst "short" is if you see the effect unmistakably in front of the target. This happens very seldom in our wet climate, at the long ranges now usual, and with the cloud of dust and smoke that is always hanging on the battlefield. Therefore, always range with a corrector 1 mil high. Such a corrector must give you one graze out of four, at short ranges, and one

out of three at long ranges. (Do not forget to make sure that it is not always the same gun that gives you this graze, because this gun may be firing with wrong data—wrong angle of site, for instance—and the other may fire much too high without your ceasing to observe one graze out of four.)

2. General Principles.

1. All rounds fired at the same *range* do not fall into the same hole. They are grouped on a certain surface of ground, around a certain *mean point.* Ranging consists:

(*a*) Either in finding one range whose *mean point* is on the target (fire for accuracy); (*b*) or, in finding one range whose *mean point* is over the target and another one whose *mean point* is short of the target.

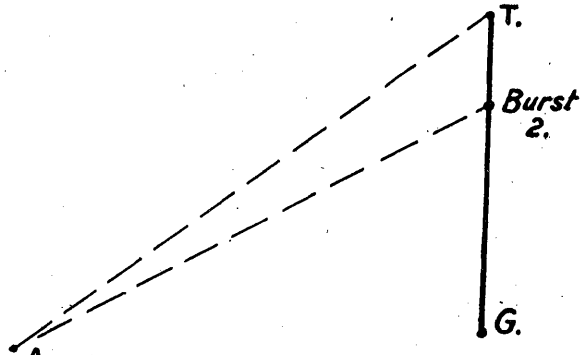


Fig. 3.

Now you cannot know *exactly* where the mean point of range is, unless you fire an infinite number of rounds on this range. But the error you are likely to make on its position, estimated from the bursts observed, decreases as the number of rounds fired on this range increases. On the other hand, other things being equal, you are more likely to misjudge a range when the mean point is nearer the target—that is to say when the bracket is growing smaller and smaller. These two considerations lead you to fire more rounds at each range when your bracket is growing smaller, and hence the following rules:

One round observed is enough to permit you to change your range

when beginning to register, but it is not enough to give you a sure sensing. You must, therefore, fire the same range again until you get *at least* a second round observed in the same way:

(*a*) If this range is to be one of the limits of your 200-meter bracket, or of any bracket smaller than 200 meters.

(*b*) If this range is to be one of the limits between which you will fire for effect, whatever the dimension of this bracket may be.

In the case of fire for accuracy, verify the limits of your 50-meter bracket by having *at least* three rounds sensed on each limit, before you try to split this bracket any more.

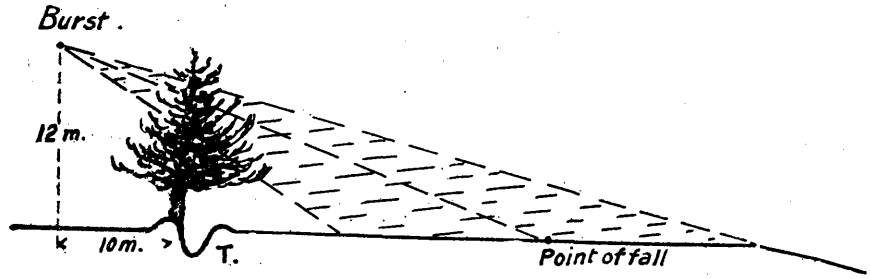


Fig. 4.

2. The normal leap between two successive ranges, when no bracket has yet been obtained, is 400 meters. This may be increased to 800 meters at long ranges if the range has only been roughly estimated, or if you want to get quickly a broad bracket on some fleeting target. It may be reduced to 200 meters if the range is approximately known from previous firing, or is measured on the map or with the range finder. It may even be reduced to 100 meters if, the range having been measured on the map, you have made the corrections for weather conditions, etc., or if you have just registered on a neighboring target and simply get from the map the *difference* in deflection and range between the two targets (both of which must be accurately plotted on the map). It may be reduced as much as necessary if there is any danger of firing on our own lines. (Theoretically the *biggest* jump permissible, when your first round has been an "over," would be equal to the distance between the target and our first line minus one dispersion zone or eight probable errors. For instance, firing at a point 250 meters from our trenches, at a range where the probable error is 20 meters, and having observed on the first range

one round over, you should not come back more than 250 — (20 x 8) equals 90 meters. You cannot always follow this rule, because it would lead to the impossibility of firing on the enemy first-line trenches when they are nearer our lines than eight probable errors—whereas it is permissable to fire on them if they are four probable errors from our lines, if the adjustment were perfect. But if you depart from the rule you must be very prudent, and you must shorten your range only after having sensed *several* rounds over. For instance, if you have sensed enough "overs" to be practically sure that your mean point is *really* over, you may safely come back by the distance between the target and our line minus four probable errors.)

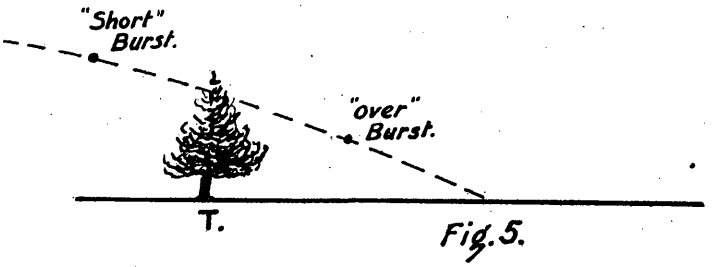


Fig. 5.

After you have bracketed the target you split the bracket. If you get a bracketing range verify this range. If it proves really bracketing, you may start your fire for effect, or your fire for accurate adjustment, without trying to get first a short limit and a long limit (see Nos. 5 and 3).

3. The smallest bracket you can get with time-fuse shrapnel is 50 meters. If you fire with shell, and mean to destroy something, you may get closer adjustment than the 50-meter bracket and try to find the range whose mean point is on the target (fire for accurate adjustment), but then you must:

(*a*) Fire each gun separately (as all guns cannot fire exactly the same range).

(*b*) Fire with the quadrant (this is not absolutely imperative but it is better).

(*c*) Verify the limits of your 50-meter bracket, as already said.

(*d*) Fire six rounds on the mean range between the two verified limits of your 50-meter bracket and get the respective position of mean point and target from the proportion of "shorts" and "overs." (Of course, if your mean point is on the target, you must get, *in the*

long run, equal numbers of shorts and overs.) You can get an *approximate* idea of the quantity by which you must change your range by following this rule: *Change your range by as many times one probable error as there are rounds you want changed from one sensing to the other in order to get equal numbers of shorts and overs.*

For instance:

8° short, three rounds observed.

8° 10′ over, four rounds observed.

Fire six rounds 8° 5′ (100 meters — 20′. One probable error = 3′).

All 6 rounds are over. Fall back on your short limit and fire on it until you get 6 rounds observed, counting the rounds observed in first getting your 50-yard bracket, if those sensings can be trusted, which ought to be the case if the rounds were fired with the quadrant. All these 6 rounds on the short limit of the bracket are short. *Then only* fire at 8° 2′.	5 overs 1 short. Fall back 2 probably errors. As this would bring you just outside your bracket, simply fall back on the short limit, and act as if all 5 rounds on 8° 5′ had been over. Some rounds fired on 8° are short, some over. Modify this range by as many probable errors as you have rounds to be changed from one sensing to the other to get 3 shorts 3 overs.	4 overs 2 shorts. Fall back 1 probable error and fire at 8° 2′.	3 overs 3 shorts, 8° 5′ is very near the target. Start firing for effect. Observe this fire for effect and change your range by 1′ or 2′ if necessary to keep your proportion of shorts at 50% in the long run.

Of course these changes by one probable error are only indications. If your range has given you four shorts and two overs, and this range, plus one probable error, gives you four overs and two shorts, do not fall back one full probable error, but split the difference and try the middle range.

4. If on one range you have only two rounds sensed, and if these two rounds have been fired by the same gun (in two successive salvos), you cannot hold that range as a sure bracket limit for the whole battery, but only for the gun that fired them, and, in the case of a broad target, for the part of the target this gun is trained on. Do not forget that:

(*a*) All guns do not fire exactly the same range (moreover, one gun might fire with wrong data, and the other bursts [lost] might be a long way off).

(*b*) The target may not be parallel to the battery front.

5. For the same reasons, you cannot safely call a range "bracketing," and fire only on this range, if it is always the same guns that are short and the same that are over (Fig. 6). On the other hand, as already said, if a range is *really* bracketing; that is to say, if you get shorts and overs from the same guns, do not continue to change your

range to get a short and a long limit, but verify this range and then start either your fire for effect or your adjustment fire for accuracy.

6. In case of a target proving to be oblique to the line of fire, you may either give different ranges to each one of your guns, or get a sure short from all your guns on the nearest part of the target, and a sure over on the farthest part. The first method will lead you to a more delicate adjustment, but, when firing for effect, will save much ammunition or will give much more powerful effect. Very often, when attacking such a target, you will first use the second method, and, after walking through once or twice, if more fire for effect be needed (fire for destruction, for instance), you will adjust more accurately, firing each gun separately.

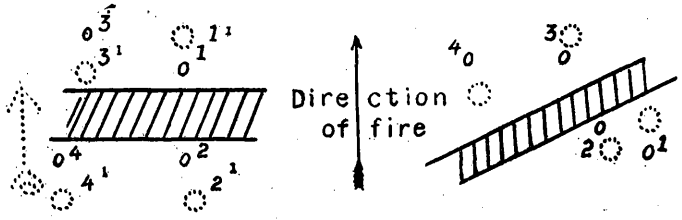


Fig. 6.

7. *If you fire by single guns, fire two rounds on each range.* One round does not give you a trustworthy indication. If you fire by battery salvos and want to register quickly, or if you have some difficulty in seeing your rounds, do not hesitate to fire "battery two rounds" as soon as you are satisfied with your distribution. It is almost as quickly fired as "battery right" or "battery one round," and gives you twice as much sensing.

8. If you have no idea of your corrector (for the first firing, for instance), better start with a corrector presumably too high. You are then less likely to lose this first salvo, even if it is too high to be sensed for range.

(*a*) You will be able to correct your deflection and distribution.

(*b*) You will know approximately how big a change you must make with your corrector, which would not be the case if your first salvo, being too low, was lost or was all on graze.

If, however, your first salvo is lost, raise your angle of site by 10 or 20. If your first salvo gives you four grazes:

(*a*) If you are sure that there is no error in your angle of site, raise your corrector by four or your angle of site by five.

(*b*) If you do not feel sure the initial data was correct, raise your angle of site by ten.

Afterward bracket your corrector, as you bracket the range. When you have fired several salvos, *take them all into account* to appreciate your corrector. Do not make changes on a few rounds which appear perchance too high or too low.

9. At the beginning of the adjustment, if you want to raise or lower your bursts by more than 5 or 10 mils, use your angle of site rather than your corrector, especially if this angle of site is already something other than zero. *Do not change your angle of site any more after the moment you get your first sensing for range*, for, if you change your site, you lose the benefit of this sensing.

10. If the site of the target is smaller than 10 mils, you better start firing with site zero, and compensate, if necessary, the error made on the site with your corrector. It will simplify the use of the tables if you want, later on, to change to shell or to fire with the quadrant.

V.

NOTES ON
FIRE FOR EFFECT WITH 75-MM. GUNS.

FIRST PART—CHOICE OF AMMUNITION—GENERAL RULES OF FIRE FOR EFFECT.

(a) Shrapnel.

1. Shrapnel is the most efficient weapon against troops in the open (except infantry, lying down, and cavalry) where the correct height of burst is obtained. It also has an inflammatory effect, chiefly when bursting low over thatched cottages, or over barns full of hay or straw.

2. Up to 1,500 to 2,000 meters percussion shrapnel is effective; over those ranges it is totally ineffective; so are too high bursts. Therefore, shrapnel is only to be employed when you have the time and means to find the correct height of burst (daylight observation from the ground and not aerial observation). The probable error in burning of the fuse increases with the distance, so that at long ranges, even with a mean height of burst of exactly 3 mils, you cannot have more than 30 to 50 per cent of your rounds effective (that is to say, between zero and 5 mils high). Therefore, as far as possible, avoid using shrapnel at ranges over 5,500 (which is, moreover, the limit of the range scale).

3. On trenches, shrapnel can have much effect when the trench is enfiladed. If this is the case the efficiency of low burst shrapnel is certain. If the trench is not enfiladed you may try to keep the heads of the infantry down with shrapnel, but you cannot expect to inflict on them any serious casualties.

4. Moreover, it should be remembered that whereas, on unprotected targets, the most effective range for shrapnel is a range a little short of the target, on protected targets, and especially on infantry in a trench, the most effective range will be a range a little over the target. (See Figs. 1 and 2.)

(b) Shell.

Shell is to be employed for all kinds of destruction work, and also for fire on troops:

1. When troops are protected (infantry in trenches, or even lying down, or in houses, cannoneers behind shields, etc.).

2. When you have no time or no means of adjusting your corrector (surprise attacks, night fire, aerial observation, big ranges, etc.).

3. On cavalry:

When are normal charges, when reduced charges to be used?

Normal charges have a big remaining velocity and small angle of fall. They must be used, therefore—

(*a*) When ricochet is wanted.

(*b*) On vertical targets, such as an embrasure.

(*c*) When the wind is strong and irregular.

(*d*) When a surprise effect is wanted. For instance, firing a few rounds rapidly without warning on a road, village, etc. The remaining velocity is almost as big as the speed of the sound, and the shell bursts before it is heard coming. It has, therefore, more chances to be efficient, besides having a big moral effect.

(*e*) At very big ranges.

(*f*) At small ranges when quick fire is needed, because the range scale can be used practically only with normal charges.

Reduced charges have a big angle of fall. Therefore they are to be used.

(*a*) On slopes going down towards the enemy, where they are much more accurate then normal charges.

(*b*) In all cases where you are undecided about choosing normal and reduced charges, because they spare the gun considerably and they enable you to fire much longer, even at a quick rate, without overheating the gun.

(*c*) When you want to break through the roof of a light shelter.

Fuses.—There are five chief kinds of fuses:

1. Black fuse, delay action 0.05 seconds (French name Fusee AR).
2. White fuse, delay action 0.02 seconds (French name Fusee SR).
3. Red fuse, delay action 0.01 seconds (French name Fusee I).
4. Long fuse, delay action 0.0 (French name Fusee IA).
5. Time and percussion fuse (French name Fusee DE 24/31).

The choice of the fuse is dictated by the kind of effect wanted. It depends on the angle of fall, on the nature of the target and on the ground. The sketches of Fig. 3 show the working of the different fuses at different ranges. The following considerations must be borne in mind.

1. *Black fuse.*—Is the most efficient fuse against personnel when it bursts after ricochet, that is to say, up to about 4,500-meter range on average level ground. Of course this range limit varies with the slope and with the condition of the ground. Most of the effect is

obtained just below the burst. As the shell bursts 15 to 40 meters from point of fall, the mean point of fall is to be slightly short of the target.

If friendly troops are close, this shortening of the range and the fact that a few splinters are projected rather far backward may prohibit the use of this fuse. Black fuses may also be used for such destruction of light shelters, that may be obtained with 75's, provided the angle of fall is such that no ricochet is to be feared.

2. *White Fuses.*—Have a smaller delay and they usually burst when the shell has just entered the ground. Because of this fact a good number of splinters remain in the shell hole. It is usually efficient on light shelters. As it removes rather a good deal of earth it may be used in conjunction with black fuses for the destruction of enfiladed parts of the trenches. It is also efficient in uprooting strongly driven in *cheveux de frise* and wiring stakes.

3. *Red and Long Fuses.*—Burst on the ground or just above it and are the most effective against personnel, when ricochet cannot be obtained. A single long-fuse shell gives more effective splinters than a single red fuse shell, but the probable error with long fuses is considerably bigger than with red fuses. Therefore, when firing for effect is started, after exact adjustment on a narrow target with a single range, red fuses will usually be preferable. On the contrary, if progressive fire on successive ranges is to be used, dispersion being of smaller account, long fuses will be preferable.

It must also be remembered:

(*a*) That shell with long fuses have not the same trajectory as shell with short fuses. Therefore, if firing for effect is to be conducted with long fuses, ranging has also to be done with this fuse.

(*b*) That long fuses must never be used either at a range giving an angle of fall smaller than 10 to 15 per cent (where they may not act) or on reduced charges (erratic rounds are to be feared).

4. *Time Fire.*—Time fire, with shell, combines some of the advantages and some of the drawbacks of both shrapnel and percussion shell. On standing, unprotected infantry, shrapnel remains the most efficient weapon. On protected infantry, time firing with shell is more effective than shrapnel, but less effective than shell with black fuses, when ricochet is obtained. This fire is not so easily adjusted as ordinary shell fire because you have to adjust the corrector—but:

(*a*) Grazes are not totally ineffective as in the case of shrapnel, but the fuse acts on impact like a black fuse.

(*b*) The effect being below the burst you can sense, on the smoke ball, even if it is higher than one mil.

(*c*) The corrector need not be so closely adjusted as with shrapnel, as the effect varies but slightly if the height of burst is between 3 and 20 meters (1 to 5 mils).

The chief danger zone of shell bursting at an average height of burst (10 to 15 meters) measures about 20 meters, perpendicularly, to the line of fire and 2 to 5 meters along this line.

Beside its material effect, shell, especially when fired in barrages, has a powerful moral effect. The points of fall are marked clearly on the ground and zone of danger is easily made to seem impenetrable. It gives confidence to our own infantry, and in fact a well-established barrage is never crossed except by quite exceptionally good infantry.

In the offensive a moving barrage or curtain of fire, besides its material effect, has a considerable moral effect on the enemy, who sees the line of fire coming slowly, but surely, his way.

Besides the black smoke of the explosions may obscure the enemy's view and cripple the efficiency of his machine guns. But it must be remembered that the material effect of shell fire, though extremely powerful, is very limited in extent. The danger zone of one single shell is not more than 10 meters broad, perpendicularly to the line of fire, and 2 to 3 meters deep. Therefore, many rounds must be fired on each range, if you want a considerable part of the ground to be covered.

GENERAL RULES OF FIRE FOR EFFECT.

I. Shrapnel.

(*a*) The height of burst of fire for effect should be 3 mils, rather less than more, especially at short ranges. It is well to keep in mind that on big ranges this height of burst will give you some grazes (about one out of five rounds at 5,500).

(*b*) *Zone Fire.*—Shrapnel will seldom be fired on a single range. Most of the time shrapnel targets will be of considerable dimensions, and fleeting, such as infantry in the open. On such targets it will usually be advisable to open fire for effect without going to a very close adjustment. Two hundred or 100-meter bracket will be sufficient in most cases—a 50-meter bracket with shrapnel should be quite exceptional. Sweeping fire will be used most of the time, the gunner giving three turns of the traversing wheel between each round, thereby displacing the bursts about 5 mils, or about 20 meters at mean ranges (20 meters are equal to the breadth of the danger zone of one shrapnel). Sweeping is done toward the left on the first range, to the right on the second, and to the left on the third, etc.

Therefore on the command—"Three rounds sweeping 4,000, 4,100, 4,200, 4,300," disposition of the points of fall would be like this (for one gun):

	20meter ←	→ 20 meter ←	→
4,300	10	11	12
4,200	9	8	7
4,100	4	5	6
4,000	3	2	1

It must be noticed that the gun finishes this fire for effect, on the deflection where it was started, only if the number of ranges ordered is an even number. If this number of ranges is uneven (say 3), the gun will be on the left of its zone. If the battery commander wants to bring it back where it was without firing another range, he will command: "Lay." It is also to be noticed that each gun fires only to the left of the deflection it started firing with. Therefore, before opening fire for effect, each gun is to be placed on the right of its zone, and not on the center of it. The third gun will therefore have to be on the middle of the target.

The interval between the initial deflection of two neighboring guns has therefore to be one-fourth of the total width of the target. The total number of rounds to be fired is equal to the front in mils to be covered by each gun divided by 5.

For instance, if the target is 80 mils wide, each gun is to cover 80 divided by 4, which equals 20 mils. If basic deflection has been marked with parallel firing, the lines of fire will already be about 5 mils apart.

The command will therefore be: "Open 15" the number of rounds to be fired by each gun on each range is 20, divided by 5, which equals 4. The only command would therefore be—"Basic deflection right—open 15, four rounds sweeping—range." Successive ranges will differ by 50 or 100 meters, according to the density of fire wanted.

(*c*) *Accurate Fire.*—Firing on one single range will happen in a few cases. For instance:

1. On a line of snipers, when this line is well seen and clear. For instance—snipers in a straight hedge. If there is enough time to adjust accurately, you will get a bracketing range or a 50-meter bracket with low bursts, and you will fire for effect. After raising your corrector by two on the bracketing range, or on the short range or the 50-meter bracket, if the infantry are standing or kneeling, or on the long range if they are lying down.

Sweeping fire will be used if necessary, that is to say, if the line is more than 100 meters long.

2. Barrage with shrapnel will be very effective so long as the correctors will be good. It is possible only if the lines are not too close together. If during an action you want to prevent an enemy attack to start from a wood or from a line of trenches, you may get a 50-meter bracket or a 100-meter bracket on the edge of the wood or trench. This done, the barrage is to be marked ("fired, only if necessary") with a range of 50 or 100 meters shorter (if it is safe).

3. For preventing the enemy from using an enfiladed section of trench. As enfiladed sections of trenches are usually short on account of the winding of the trenches, fire has to be adjusted accurately, both in deflection and range. Fire for effect (so many rounds a minute) will be executed usually with a single gun on a single deflection and a single range (the range whose mean point is nearest to the middle of the enfiladed section).

II. Shell—Zone Firing.

1. As the danger zone of one shell is considerably smaller than that of one shrapnel, the zone within which fire for effect is executed will be reduced as much as possible. This will be relatively easy as many of the targets (mostly trenches or stationary infantry) will admit accurate adjustment. It will very often be found necessary to give different ranges to each gun, to place an oblique target inside a narrow bracket.

Sometimes, when firing percussion shell, it will be found handy to change, if necessary, the angle of site of some guns (by multiples of 5 mils) and to give the same range to all guns. Inside the zone thus indicated, fire for effect will be conducted on the same lines as zone fire with shrapnel, with the following differences:

Successive ranges will differ by only 25 meters. These jumps of 25 meters may seem rather large when it is considered that the danger zone of one single shell is only a few meters deep, but 25 meters is, at all ranges, smaller than three probable errors, and we know that when successive ranges are not more than three probable errors apart, the rounds are evenly distributed on the ground. If more powerful effect is wanted, more rounds are to be fired at each range, but it, is no use making jumps smaller than 25 meters (which is the smallest change possible on the ranger scale).

2. Ordinary sweeping fire displaces a burst 5 mils in deflection and this is too much at long ranges with shell, as the danger zone is only about 15 meters broad. If it is wanted to distribute the rounds quite evenly on the ground, you may either give the command: "Sweep by one turn" or, after walking through once with ordinary

sweeping give the command: "Left one turn," before you walk through again.

For instance, the bracket being 4,300–4,350, the commands would be:

(*a*) Three rounds sweeping 4,300–4,325–4,350 (rounds 1 to 9).

(*b*) "Lay"—Left one turn 4,300–4,325–4,350 (rounds 10 to 18).

(*c*) "Lay"—Left two turns 4,300–4,325–4,350 (rounds 19 to 27).

For One Gun.

5 mils			x			5 mils			
x	0	*	x	0	*	x	0	*	
27	18	9	26	17	8	25	16	7	4,350
x	0	*	x	0	*	x	0	*	
22	13	4	23	14	5	24	15	6	4,325
x	0	*	x	0	*	x	0	*	
21	12	3	20	11	2	19	10	1	4,300

The above table shows the fall of the rounds, the asterisks being the first series, the 0 the second and the X the third.

The total number of rounds to be fired depends upon the importance of the target. It has been found that when ricochets were obtained or when time-fuse shells were bursting at a proper height, 100 rounds being fired in each square 100 meters on each side (40 rounds per acre) the zone of fire covering the target, the percentage of hits was 50 per cent both on men inside a trench and on cannoneers at their position behind guns provided with shields.

To take a concrete case: On a trench 100 meters long, on which you have got a 50-meter bracket, the desired results will be obtained if you fire a short, middle, and long range, each gun firing six or seven round each range.

III. Accurate Fire.

Accurate fire with shell (fire for destruction) will usually be registered by separate guns. The mean point will be brought on the target by means of a series of six to twelve rounds. All precautions will be taken to reduce the dispersion as much as possible (use of the quadrant, short fuses, reduced charges, chiefly on ground sloping down toward the enemy, and of course careful selection of ammunition). If necessary, fire for effect may be conducted by the four guns at a time, but from time to time each gun will have to be verified separately by firing a series of twelve rounds. During this time the other guns will be cooled down.

Another fire that is to be accurately registered is "barrage." The best way will often be to adjust the barrage on the enemy's first line

(very often by separate guns) and then to reduce the range as much as possible with safety.

Barrage is to be started as near our own front lines as is safe, to get it to fall ahead of the storming parties, even if there is a slight delay in opening firing. After a few minutes of firing the range will be increased by slow changes of 25 meters until the barrage reaches the first lines, where it settles.

If the attack has not started before, it is by firing on this line, where the enemy is obliged to mass his men, that the attack is most likely to be checked.

IV. Gas Shells.

Gas shells are efficient to neutralize the enemy. They can actually kill them only if firing is long enough and dense enough to exhaust the chemical substance contained in the German respirators (each man has two) or if it is so sudden that the men have no time to put them on.

Neutralizing firing will almost always be effective, especially against artillery, where the men cannot leave positions, and they will find it very hard to work the guns with their respirators. Fire will be opened by surprise, usually after registering on some auxiliary target with ordinary shells of the same weight and same charge as the gas shells.

The fire will be rapid for a few minutes (say 15 to 30 rounds per gun). Then firing will be slowed down to a few rounds per gun per minute, one platoon firing while the other is cooling down. Quick firing is started again from time to time. If possible the accuracy of adjustment is verified. The danger zone of the 75 shells (gas) is only 10 meters in diameter. Its noxiousness is much diminished when it has drifted about 50 meters under the influence of the wind.

Firing is therefore to be directed on a point close to the target on the side where the wind blows from. If the target is not well seen, or is not seen at all, zone fire may be necessary, but of course the number of rounds needed will have to be much greater. The efficiency is very much diminished by very heavy rain and wind. Never fire gas when there is a wind blowing higher than 3 meters per second (3 meters per second is the speed of the wind which you just begin to feel in your face, or when it just rustles the smallest branches of the trees). The best results are obtained in woods where the gas cloud keeps hanging on the branches and leaves and

in ravines, as the gas (heavier than air) gathers in all the lower parts of the ground.

The gas cloud is broken up by explosions, and it is therefore not advisable to fire gas shells and ordinary shells on the same target at the same time. Neither is it advisable to fire more than six rounds a minute with gas shells for the same reason.

PART TWO—FIRE FOR EFFECT OR WAR IN THE OPEN.

The general principles governing fire for effect, being thus understood, let us illustrate them by a few concrete examples. Let us consider, first, war in the open, the term war in the open being used here in opposition to trench warfare. In war in the open, fire may be directed against artillery, infantry and cavalry.

Artillery Targets.

(*a*) *Artillery Whose Guns Are Seen.*—Such artillery is doomed. The enemy will not place his guns in sight, but it may happen in the course of fighting that we should capture a crest giving us a view of the enemy's artillery.

If the battery is seen in the open and is firing, the first thing is to register with shrapnel on broad limits, both for deflection and range, and to walk through two or three times to oblige the enemy to cease fire, inflict on them some casualties, and prevent them from limbering up. This result being obtained, fire is continued with shell on narrower limits to reach the personnel behind the shields and to obtain some effect on the matériel. It has been seen that if the personnel has no other protection than the shields, a density of fire of forty rounds per acre (100 rounds per hectare) may cause 50 per cent casualties among the crews. If the situation allows it, fire for destruction may then be directed successively against each gun, one gun being employed at a time on this task while the others fire a few rounds from time to time on the rest of the battery, or simply keep ready to open fire again in case the enemy battery should try to open fire again. For instance the fire might be conducted like this:

Target: Three guns seen on the edge of a wood.
Basic deflection, left 100; open 10; site 0.
Corrector 18, Battery right, 3,000 (short)
Corrector 20, Battery right, 3,400 (over)
3,200 (over)
3 rounds sweeping, corrector 22 — 3,200–3,100–3,000
3,050–3,150
3,200–3,100–3,000

(The enemy's battery has ceased fire; the fourth gun has been discovered on the right—the sheaf is now adjusted.)

Left 5, close 5 — Normal shell, black fuse.

Battery right 3,200 (short),
3,400 (over),
3,300 (short).

Battery, five rounds, sweep by one turn:

3,300 – 3,325 – 3,350 – 3,375 (3,375 is seen over),
3,375 – 3,350 – 3,325 – 3,300 (3,300 is seen short),

Second, third, fourth section—one round a minute, 3,325 and 3,350.

First gun at my command:

First gun, left three; four rounds—3,325 (O,S,S,S) 3,350 (O,S,O,S).

Right, one—3,350 (O,S,S,O); 3,350 (O,O,O,O); 3,350 (S,O,O,O); 3,325 (O,S,O,S); 3,325 (S. O.—*Target*).

First gun suspend fire. Second gun at my command, etc. . . .

If the enemy tries to open fire again on the left of the target:

Second platoon, ten rounds, 3,350 and 3,325 . . .

(*b*) *Artillery Seen by Its Flashes.*—Some flashes being seen, the middle of a 6,666*d broad* sheaf is to be placed on the flashes, the sheaf being at least 20 mils broader than the target seems to be. For range, a sure short is usually easy to obtain. For instance: A short on the crest hiding the guns or a short on the edge of the woods from which the guns are firing. Sure overs will be usually more difficult to get. You may get them when you see your rounds bursting in the open ground on the counter slope behind the crest or behind the mask. Sometimes you will be obliged to assume a long limit for your fire for effect, being guided by considerations such as the slope (known from the map or otherwise estimated) or such as, the impossibility for rifled guns to be far inside a thick wood. Between these limits fire for effect, first with shrapnel and then with shell, as in the case with guns seen in the open. Of course, the last phase (fire for destruction) is to be omitted.

Infantry Targets.

Infantry may be seen on the battlefield in very varied forms which have to be met with varied methods of fire.

If the infantry is standing (marching or attacking) shrapnel is the most efficient weapon, especially if the range is not too big, but if the target is fleeting you will often not have time to adjust your corrector and may have to fire shell.

First example.—A column of infantry seen marching on a road at a long range.

Prepare fire as correctly as possible, in a short time, from the map. You may even fire a few rounds, but fire away from the infantry so as not to attract their attention. Then shift fire to them and from this moment fire as quickly as possible. For instance: You measure on your map: site 0, 6,400. Basic deflection, right 100—open 15. A. L. Shell—Green Fuse 14°, 12°.

(The second salvo (12°) being fired without waiting for observation of the first, both are observed at the same time). Should the target be bracketed, start at once fire for effect. Four rounds sweeping, 14°; 13° 30′; 13°; 12° 30′; 12° (the fire is seen to cover the target, though you see more "overs" than "shorts" drop the 2 longest ranges and "fire again"), 13°; 12° 45′; 12° 30′; 12° 15′; 12°, etc.

If the range were shorter, shrapnel would be better, especially if the corrector was already known. If not, it is sometimes possible to adjust it on another target before shifting fire to the infantry.

Second example.—An enemy counter attack, rushing out of a wood to meet our men holding a hedge a few hundred yards off.

Try to get one salvo—with shrapnel if corrector is known, with sheel if not—between the attacking line and our own line and open fire for effect on this range (if the distance between the attack and our line is small) or on this range and successive increasing ranges (if the distance between the lines is a little bigger). Do not try to have both a short and an over before you open fire for effect unless the distance between the attack and our line is considerable (more than 500 or 600 meters).

Third example.—A thin line of enemy snipers in a hedge is holding up our attack. Get a narrow bracket on the hedge (50 or 100 yards) and fire for effect (shell, black fuse and time-fuse shell) on the bracket limits and intermediate ranges.

Fourth example.—A machine gun checks our advance. A heavy fire (shrapnel or shell) is *a once* to be directed against it. One gun firing rapidly is better than firing with the whole battery, except when the position of the machine gun is so uncertain that a big zone has to be searched. Fire for effect has to be started on a broad bracket (200 meters, for instance) the fire for effect being observed, to drop useless ranges later on.

Fifth example.—Infantry holding a village. A bracket of 100 or 50 meters is to be obtained on the outskirts and fire for effect is to be made with shell between its limits. The inside of the village, and especially the streets, will be searched with shrapnel, if the

houses are low or if the streets are enfiladed, with shell (time fuse, a red or long fuse), if the houses are high and the streets are not enfiladed shrapnel may also set the village on fire, especially if the barns are full of hay.

Sixth example.—Infantry crossing a crest in small groups, coming forward to attack our line.

One battery may establish itself in observation on the crest, with a very broad sheaf, guns in abatage, in the middle of their zone. The range and corrector of the crest will be registered so as to be ready to start a heavy barrage in case any considerable body of troops should try to cross the crest. Furthermore each gun should be registered on two or three conspicuous points in its zone, choosing points affording possible shelter to the enemy (ditches, roads, hedges, and so on). If a party big enough to attract fire appears, fire will be opened without any further adjustment by the gun or guns in whose zone the target appears.

But if the enemy is to attack they will first have to assemble their men. They will usually do this under some kind of shelter or cover, close to their first line (small woods, hedges, ravines, and so on). The range of these points will be registered—by another battery preferably—timely fire on these points may ruin the enemies' prospects of attack. But in case the attack should be started, nevertheless, this battery will also have registered a barrage and will be able to fall back on this barrage the moment the attack starts. Of course, in this case, the battery watching the crest will join in the barrage, keeping all the time ready to fire again on the crest if any considerable detachment attempts to cross it.

Cavalry.

Cavalry is to be attacked with shell, these having a considerable morale effect both on men and horses. If cavalry is charging towards the battery a shell barrage is the best way to stop them. If the cavalry is crossing the battlefield transversally the guns are to be put on a very broad sheaf, each gun being fired at the B. C.'s command when the cavalry enters its zone. Of course if direct laying is possible all guns aim at the cavalry and are fired at the same time.

Staff Parties, Reconnaissance, Battery Details.

These afford very important but fleeting targets. Fire for effect will be opened with shrapnel on very broad limits (400 m., for instance) or even, only a short having been observed, the range being

increased by jumps of 100 or 200 m. until the fire is seen over—or the target has disappeared. The bracket will be reduced if the target has not disappeared after the first walking through.

PART THREE—FIRE FOR EFFECT IN TRENCH WARFARE.

Sometimes in trench warfare you get targets similar to those of war in the open. Of course, they are to be attacked in the same way, taking, however, advantage of all the facilities offered by trench warfare (such as accurate maps, knowledge of weather conditions, good observation system, ground already registered, and so on).

But there are also targets special to trench warfare. Let us see the best way to fight them. We will consider first, artillery targets, then infantry targets when none of the parties are attacking, when we are attacking, and when the enemy are attacking.

Artillery Targets.

Most of the enemy artillery will be under the shelter from 75-mm. shells. It will usually be impossible to destroy the guns except by embrasure hits; but 75 guns will nevertheless be sometimes able to neutralize some batteries, either with gas shells or by firing a great many rounds on the battery. Even if no direct hit through the embrasure is obtained, the telephone communication must be broken, ammunition dumps may be exploded or set afire, splinters may disable some of the gunners, especially those who have to work outside the casemate, and so on.

Most of the adjustment will be done by aerial observation. If the target is very clearly seen by the aerial observer, and if the range is not too big, fire for destruction may be attempted even if the guns are under casements (embrasure shots).

In this case each gun is to be registered individually, the mean point of impact being placed on one of the enemy's gun pits. Of course the fire must be as frontal as possible, and normal charges used. The aerial observer observes as much of the fire for effect as possible.

If fire for destruction is not wanted, or is not possible, a 100 or 50 meter bracket may be obtained by aerial observation and fire for effect will take place between these limits.

As soon as the aerial observer leaves, after having adjusted the battery on the target, the battery commander must register correctly on one prominent point seen from his observing station, this point being as near the target as possible. He will use this point as an *auxiliary target*, if he is to fire on the same target again without

the help of the aerial observer. If the difference in range and deflection, between the real target and the auxiliary target is very small, this difference may be assumed to be constant, even if weather conditions change.

Sometimes fire on a battery will be opened without any direct adjustment. This is possible only if the target is accurately plotted on the map (from aerial photos, for instance). In this case the battery commander adjusts his fire on another point, also correctly plotted on the map, and as near the real target as possible. He then shifts his fire in range and deflection by the quantity shown on the map. Sometimes even (at night, for instance), registering on an auxiliary target is impossible. In this case, fire may be opened from the map, all weather corrections be accurately accounted for.

Of course, in all these cases, fire for destruction is out of the question, and fire must be executed *on the range calculated, and between limits, three theoretical probable errors shorter and three theoretical probable errors longer.* At average ranges this means firing the range calculated 50 m. shorter and 50 m. over. If weather conditions are correctly known and accounted for, such fire will surely cover the target.

Gas shells are very often used to neutralize batteries, especially during an attack, when for some reason or other destruction cannot be contemplated. They are especially advantageous on groups of batteries close together (what we call batteries' nests, in the French Army), especially in woods. Such fire is efficient when it is well directed, sufficiently dense, and lasts long enough (many hours). The weather conditions have also to be favorable (no heavy rain, and very little or no wind). Moreover, fire with gas shell is only to be opened on order from the Divisional Artillery Commander, and not on Battery Commanders or Battalion Commander's own initiative.

FIRE AGAINST INFANTRY WHEN NEITHER SIDE IS ATTACKING.

Fire against infantry will be of different kinds.

A. *Neutralizing fire* to keep the enemy down when their fire is wearing our own troops; get a 50-meter bracket, possibly with different ranges for each gun. Fire rapidly on the short, middle and long range (2 to 5 rounds for instance, usually shell, black or red fuse, according to range). If the enemy starts firing again, after a few minutes, fire rapidly, twice as many shells as before.

B. *Retaliation Fire.*—It is often ordered when the enemy have been firing on our own lines or on the rear. This fire is usually directed on villages, cantonments, commanding posts, and so on, but may also be directed on trenches, chiefly if the enemy have been firing on our own trenches, or if there is some chance of doing some harm by firing on their trenches. Therefore the targets and hour will be chosen to insure efficiency (enfiladed trenches, and communication trenches in the region where the men's dugouts are built, at dinnertime, for instance). Fire must be unexpected and very rapid. It is to be registered accurately some time before (between 5 minutes and half an hour) on an auxiliary target. Fire will be then shifted, from the map, or from the result of previous fire to the real target. When opened, fire for effect is to be as quickly finished as possible. It ought usually not to last more than one or two minutes. If heavier fire is wanted, use more guns. For instance, three rounds, sweeping by one turn, 4,200, 4,225, 4,250, 4,275 and 4,300, all fired in one minute.

Care must be taken: (1) Not to take always the same auxiliary target for firing later on a given target. (2) Not to fire for reprisals always on the same part of the enemy's line. (3) Not to open retaliation fire on the part of the enemy's trench *just* opposite the part of ours which they shelled, for in all these cases the enemy would be on their guard and fire would be ineffective. But on the other hand as the purpose of this fire is chiefly to keep up the morale of our infantry by showing them that the enemy cannot shell them with impunity, retaliation points must be near enough to our lines that the men can see or at least hear the shelling.

C. *Concentrations of Fire.*—Heavy fire may be obtained on some parts of the enemy's lines by concentrating the fire of several batteries. Such fire is opened when there is reason to believe that something is going on in the enemy lines (warnings of preparation for local attack, new work, where many workers are probably assembled). Fire is opened at the same time by all the batteries. When possible, enfilading fire will be employed by some of the batteries, jointly with frontal fire by some other batteries. Each battery will have registered inconspicuously on an auxiliary target, and takes from the map, or from previous firing, the difference in range and deflection. The time for starting fire for effect will be given beforehand (not by telephone, unless ciphered) and will be scrupulously observed. Fire for effect (usually on successive ranges) is not to last more than a few minutes, until, in fact, it may be assumed that all men have had time to get under shelter.

D. *Destruction fire on trenches* is very seldom attempted by 75's and then only when enfilading fire can be used. Deflection and range are to be correctly obtained and fire for effect will be made on one single range. Shell with black and white fuses mixed will usually give the best results. Ten rounds per meter of enfiladed trench are usually sufficient to really damage the trench.

E. *Destruction of Machine Guns.*—Most machine guns will be under shelter and their destruction by 75's will be very difficult. It is seldom attempted when no attack is contemplated unless the machine gun is very troublesome (enfilading one of our communication trenches for instance, causing casualties, and not willing to be silenced by retaliation fire or bombing).

In this case, if 75's are the only guns available, the machine gun can be destroyed by a direct hit through the embrasure (shell, normal charge, black or white fuse) but the fire has to be conducted (on a single range, of course) from a point where the embrasure is clearly seen at the short range. Even in this case it may take several hundred rounds to get the result, which is more than the usual allowance of a battery in a quiet sector.

F. *Destruction of Trench Mortars.*—Fire is to be conducted much in the same manner as against a machine gun, but the mortar will be more easily spotted, though perhaps less accurately. (Careful examination of aerial photos may help a good deal); the target will be considerably bigger, as it will very often not be casemated. Even if it is, the embrasure will be made for firing under an angle of 45°, instead of being a vertical one, therefore reduced charges are to be used. If absolutely accurate fire is impossible, the target not being clear enough, some results may be expected from heavy firing on a small zone, 50 to 100 m. The result will often be the silencing, at least for some time, of the trench mortar. Even if no direct hit is obtained the gun may be damaged by splinters, ammunition may be blown up or set on fire, or infantry in or near whose trench the mortar is, and who received part of the shelling, will beg the officer of the Trench Mortar Company to move a little and moving trench mortars involves heavy work.

G. *Harassing Fire* is generally used when it is thought that the enemy are preparing some attack in the sector or want to move part of their troops away. In this latter case it is used generally with some concentrations of fire and some destruction fire to make the enemy fear an attack of ours. It consists in firing a few volleys at irregular intervals, day and night, on the points of passage (villages, enfiladed roads and paths, enfiladed communication trenches, etc).

Most of this fire is night fire from the map, taking account of weather conditions. Such fire will sometimes be conducted by one or several platoons, changing their position constantly. The fire for adjustment on all these positions, may, if the firing is well conducted, lead the enemy to believe that we are increasing the number of batteries in our sector and therefore preparing for an attack.

H. Infantry in the open will sometimes be seen, generally at daybreak or when the mist lifts. Parties of workers, or of men walking in the open to avoid wet communication trenches, may thus be seen. But when taken under fire, they will disappear almost instantly, and you will seldom be able to fire more than a very few volleys. Therefore if the target is worth firing upon, fire for effect must be started at once from the results of previous firing or from the map, taking weather conditions into account.

Generally speaking, in a sector, fire for adjustment is very much simplified by the fact that you can use ground sensings very much. The ground is so well known that; seeing a point of fall, you could even give its coordinates. For instance you are firing on the second line trenches and your first round falls behind it but in front of the third line. You know (from the map, and better from previous firing) that the distance between these two lines is only 100 yards, you can safely jump only 100 yards.

Lateral observation is also rendered much easier by the fact that you are able to open fire with a correct deflection, in fact if you are firing a point clearly plotted on the map and take account of drift differences and of wind, you will open fire, generally, with an error smaller than 5 mils and you very seldom have errors greater than 10 mils.

It is this knowledge of the ground and the correct plotting of battery positions and targets, as well as the careful keeping of the data previously obtained, that makes rapid firing almost or completely without adjustment, relatively easy.

VI.

NOTES ON

BATTLEFIELD APPLICATION OF THE FIRE OF 75 MM.

Fire on Infantry and Trenches when We Are Attacking.

(*a*) *Before the Attack.*—Before an attack is launched on fortified positions there must be a complete artillery preparation. The enemy defenses must be at least partially destroyed, the morale of the enemy must be kept low by keeping the troops constantly under fire, preventing food and reinforcement from arriving to the first line. His physical and intellectual strength must be impaired by heavy bombardment, rendering any rest or sleep impossible for days and nights running, by gas bombardments and so on. As many as possible of his batteries must be destroyed.

The 75's part in this preparation is chiefly:

1. Destruction of wire.
2. Prohibitive fire on roads, paths, enfiladed communication trenches.
3. Fire on all parts of the trenches that are not for the moment fired at by heavy artillery—to prevent the enemy from getting any rest and fire on second and third lines while the trench mortars are at work on the first line to prevent the enemy observers from spotting our mortars.
4. Night firing on all points where destruction fire has been made during the day—to prevent the enemy from repairing them.
5. Occasional "tremmelfeuer" and beginning of the curtain fire to lead the enemy to believe that the real attack is going to begin—with the double idea of making him disclose his barrage system by guns and machine gun—and of making him doubt when the real attack will be started, whether it is really the attack or not.
6. Concentration of fire with shell or gas shell on reserve camps, etc., behind the lines—or on village roads, etc.—where reinforcements are reported to pass.
7. Counter-battery work.

1. *Destruction of Wire.*—Wire in front of the first line is usually destroyed by trench mortars. The 75's are called to open gaps in

wire entanglements out of range of trench mortars. The infantry wants clean cuts, about 25 meters broad across the wire. These cuts must be close to each other so that the infantry shall be able to run through without changing its formation. There must be two of these gaps every 100 yards.

Now, the heavy artillery is battering these second-line trenches. They do not usually try to destroy the trench completely, they only fire on some points 30 to 50 m. apart, leaving between them short sections of trenches badly damaged but not destroyed, but devoid of communication with one another. It will often be possible for the 75's to open the gaps in the wire in front of the destroyed portion of the trench. The dispersion in range will have brought some of the heavy artillery rounds to fall in the wire (provided the wire is not too far from the trench) and the task remaining to do for the 75's will be easier. Now the total width of the gap will be 20 to 25 m. This will be obtained by placing the mean points of each gun 5 m. (or a little more than 1 mil) apart. This being less than the 50 per cent zone of dispersion in deflection it will not be necessary to sweep. As for range the probable error is, at usual ranges, between 15 and 25 m. If the wire is not much more than one probable error deep fire has to be conducted on one single range. If the wire is deeper than 1 or 1½ probable error successive ranges differing by about one probable error will be used. If, as usual, the system consists of several belts of wire it is as well to treat it as if the space between the two belts was also covered with wire unless this space is bigger than about 1 probable error, in which case better results will be obtained by firing independently at the two entanglements. The width of the entanglement being known it is easy to find out what is the best method of fire in each case. At any rate, fire has to be accurately adjusted by each gun separately. All guns may fire at once for effect, if rapidity is wanted, but from time to time it will be well to stop the fire of three guns and verify the ranging of the fourth.

To take an example, suppose 2 belts of wire 6 meters deep separated by an open space also 6 meters deep, the total depth of the system is 18 m., or about equal to one probable error. Therefore fire on one single range (the range whose mean point should fall in the middle of the open space) will be as effective as fire directed first on the first entanglement, secondly on the second entanglement.

Each gun is adjusted accurately (with reduced charges if any are available, even on level ground, as the guns do not get so quickly hot) red or white fuse, the mean point being brought in the center of the open space. A gun will be considered to be adjusted only when

out of a series of 12 rounds, 5 or 6 being sensed short (overs), 5 or 7 over (short) (all rounds in the near entanglement being called shorts, all rounds in the further being called over, all rounds in the center being called targets).

The 4 guns being adjusted and placed about 5 meters apart, a series of 24 rounds may be fired by all guns. Then the two guns of the first platoon will fire successively each 12 rounds to have their range verified. Meanwhile the guns of the second platoon are cooled down. A new series of 24 rounds is fired by all guns, after which the first platoon is cooled down while the third and fourth section are verified, etc. Of course these numbers are only given as examples.

The number of rounds to be fired is, at 4,000 or less, 500 to 600 if the total depth is 25 m., 900 if it is 50 m., at 5,000 about 1,000 rounds (these are average numbers, on level ground). If the entanglement is not clearly seen and if it is necessary to fire on successive ranges these numbers must be considerably increased—and destruction of wire becomes almost impossible without aerial observation. Wire is best destroyed by batteries whose direction of fire is as near as possible to the normal. The gaps are then perpendicular to the direction of the entanglement. Oblique fire is to be avoided, as the gaps made are also oblique, with the result that our storming parties will have to parade obliquely in front of the enemy trench instead of going squarely for it.

Enfilade fire may sometimes be used, but great care must be taken to open the sheaf enough to cover the whole of the entanglement; the probable error in direction being very small if the right gun is a few meters off the right limit of the target there might quite well remain a very thin entanglement which might be enough to stop the attack. On this account it will usually be necessary to fire about the same number of rounds with frontal fire to make sure of an opening, but then, the opening will prove broader than with frontal fire, in fact if the center of two neighboring gaps are chosen 50 meters apart and if fire is by enfilade the two gaps will almost or completely meet. So enfilade fire, when completely enfilading permits, with the same amount of ammunition, to destroy the whole of the wire (instead of destroying half of it with frontal fire) but it does not permit reducing appreciably the number of rounds to be fired to obtain one individual gap.

2. *Prohibitive fire on roads, paths* and so on is made as shown before, chiefly at night. Usually each battery has a few hundred rounds to fire in this way during the night.

3. *Fire on the trenches* when these trenches are not otherwise

beaten. Nothing special to say about it, except that if the fire is not accurate (enfilading or 50-m. bracket) the enemy will not take any account of it.

4. *Night firing* to prevent destructions being repaired. A very important item. It is no use spending many hundred or thousand rounds in cutting wire during the day if the enemy is allowed to repair it—which is comparatively easy—at night. Before nightfall therefore an accurate fire (shell, long or red fuse) is adjusted on all the points where destructions have been made and salvos are fired at quite irregular intervals on their ranges (modified to take account of weather conditions) and on ranges 50 m. shorter and 50 m. longer. The light artillery ought to be considerably helped in this task by machine guns firing on the first and even on the second line (indirect fire if necessary). If a good cooperation between artillery and machine guns is established it is almost impossible for the enemy to repair his works, while much artillery ammunition will be spared for other purposes.

5. *Occasional trommelfeueur* and beginning of curtain fire to deceive the enemy, nothing special to say except that enemy will not be deceived unless the game is thoroughly well played. It is useless to simulate an attack when it is evident that preparation is not finished. Also the difference in speed of fire must not be too great. If you overdo it the enemy will at once see that you are not in earnest.

6. *Concentration of fire* gives very good results in a sector where the enemy is likely to have massed troops to meet our attack. They are very heavy (sometimes 20 to 30 batteries) so that the importance of checking the watches is evident.

7. *Counter-battery work has been seen* in fighting the artillery during the attack. Let us see what may be the targets and kinds of fire of a 75 battery during the actual attack. When the attack is started the enemies' defenses will be pretty much wrecked, but unless the ammunition allowance for the heavies has been enormous there will be stretches of trenches left, with, possibly, some dugouts. The task of the field artillery, in accompanying the attack, consists in preventing the enemy left in the remaining dugouts to man what remains of the trenches. To accomplish this task the 75's will have adjusted carefully on the first-line trench and on all trenches which may support the first-line by their fire. (Usually 50-m. bracket for each gun or 100 m. for the whole battery.) Heavy, but *irregular*, fire within those limits during a few hours will keep the defenders down.

Two or three times during this fire the batteries firing on the first

line will have increased their range progressively and swept over the zones of shell holes between first and second line, and then will have come back rapidly on the first line, possibly catching the enemy in the open trench, masking an attack. During this bombardment it is well, if the distance to our own line is safe, to sweep several times over the zone of shell holes in front of the German trench—as the Germans have found out—as we have—that very often the best way to avoid a heavy bombardment on the first lines is to crawl forward into shell holes in No Man's Land. As the hour of attack is nearing, all batteries are inconspicuously brought to bear on the first line or on the lines giving fire action on the ground where the attack is to take place. The speed of fire is not to be altered. Some guns keep on firing between the first and second line to keep possible machine guns in shell holes down.

The fire on the first line is not lifted when the attack starts but only when the fire becomes dangerous to our approaching infantry. It is then moved progressively over the ground between first and second line. The speed will have been given beforehand (infantry cannot walk fast over ground broken by shell holes; usually they try to run over No Man's Land so as to have crossed it before the enemy's barrage is started. Once over the German first line this barrage will be much more hesitating and uncertain. Very often the speed of advance will be 50 to 100 m. per minute for the first few minutes, then 25 m. per minute). This moving barrage or curtain fire is usually the best when two batteries in one battalion use sweeping fire with shell, with increases of 25 m. between each range, while the third battery is firing shrapnel some distance ahead of the barrage. As far as possible, all his "curtain fire" has to be done by batteries whose line of fire is perpendicular to the trenches—to avoid changes in deflection—of course, as soon as the enemy has discovered the attack, there is no reason not to increase systematically the fire on the lines commanding the ground of the attack. If the enemy mans these firing lines under heavy fire he will do so at the cost of many casualties and smoke will cripple the efficiency of his fire—if he does not man them this neutralization is worth the ammunition.

The batteries engaged in this task will have to keep a sharp look-out for machine guns. Any machine gun disclosing itself will be *at once* taken under heavy fire, under the battery commander's own initiative.

Every battery commander seeing a machine gun firing unimpeded on our troops in the open has to take it immediately under fire, but as a rule this ought to be done by the batteries firing on the second

lines, as the batteries firing the curtain fire cannot easily leave it. It would be impossible to fire the curtain fire with three guns and to attack a machine gun with the fourth at the same time, and the abandonment, even for a short time, of the moving barrage will cause hesitation and wavering in our storming parties. If, therefore, a battery commander, firing on the second line, sees a machine gun opening on our troops, he will at once shift the fire of one or two guns to it and start immediately very heavy fire for effect. If the gun is seen, the zone of fire will be reduced as much as possible; if there is some uncertainty about the machine gun's location the whole suspected area is to be swept by the whole battery if necessary, regardless of cost. In big attacks this fire will usually not happen because the cloud of smoke will be too heavy to allow any observation after the beginning of the attack. These batteries will also have registered the ground carefully so as to concentrate all their fire without registering on any attempted counter attack either upon order received (in this case even simply by firing from the map) or upon the battery or battalion commander's own initiative if he sees something. In case of a counter attack the batteries firing the curtain fire in front of our attacking wave will simply increase the speed of fire and will establish a heavy barrage in front of our troops.

(*b*) *After having carried the first few lines of trenches* the attacking waves will be rather disorganized—men of different units may be somewhat mixed together, losses will have to be made good, fresh ammunition supplies will be wanted, and, over all, the men will be tired. The attacking wave will therefore have to halt. The line where this halt is to take place will have been given beforehand both to artillery and to infantry. This line is chosen so as to be easily recognized by our own troops without being easily found out by the enemy. Enemy lines of trenches are to be avoided as the enemy artillery could too easily be brought to bear on them with accuracy. The line will rather be described this way, "200 m. east of the enemy's second line trenches up to the point where they cross the road—then 100 m. east of the road until it enters X village—then skirting the village to the east 100 to 200 m. from the houses." As soon as the individual infantry battalions or companies reach this line they settle down and make some kind of elementary defensive works. Their machine guns are brought up ready to open on counter attacks, etc.

The batteries firing the curtain fire establish a barrage in front of this line. It is, however, to be avoided to make the line of barrage continuous in front of the infantry—the barrage would give the

infantry position away—so the batteries will register their barrage and will not fire any nearer, but they will fire not only on the barrage but also further, sweeping over the ground. For the first few minutes the barrage will have to be heavy as the infantry is not able to protect itself with efficiency. After some time, when the machine guns are ready to fire, when order is beginning to be restored, etc., the speed of fire will be progressively slackened, and part of the guns will cease firing, to be cooled down, remaining of course ready to open quick and accurate fire again without delay in case of an emergency.

Meanwhile the artillery preparation on the remaining lines of defense is going on; field artillery firing on this line will prevent our infantry being worried by rifle fire. Possible machine guns in the open ground will be attentively searched for and if seen, taken under heavy fire, but the smoke will usually prevent them from being detected and the destruction of machine guns will therefore necessitate systematic zone fire. All places affording possible cover to machine guns (hedges, ditches, sunken roads, small woods, ruined buildings, are subjected to searching fire). The machine guns may thus be destroyed, or at least crippled, if they have been hastily brought in position outside the lines of trenches to check our advance. (Prepared strongholds holding machine guns between the lines of trenches are also frequent, but their destruction is to be entrusted to heavy artillery.) Another task resting with such field artillery as is not firing the barrage will be to check counter attacks in the bud. This will be done by enfilading fire on all communication trenches and roads (observed fire if possible, if not, zone fire, *accurately* prepared from the map), and by systematic zone fire over all the places where such an attack might be started from (small woods, ravines, ruined villages, systems of trenches, etc.).

During this halt, which may last any time from a few minutes to a few hours, any part of the proposed halting line that our troops have been unable to reach in time will be subject to a small local attack preceded by an extremely heavy concentration of fire by guns of all calibers. The infantry that made the first attack is reinforced in their new line by their battalions which cross the open ground in small groups under protection of heavy neutralization fire on all the lines that may have fire action on this zone, as well as on all the enemy's observing posts. These new infantry may carry the next stage of the attack, with the help of the infantry that already carried the first line, or alone, leaving the already exhausted infantry behind to organize the line they conquered in case the next attack should

fail and the attacking troops had to fall back to this line. At the time appointed, beforehand, or on some signal. (for instance, 17 minutes after a special rocket is fired from the divisional observation balloon) the second stage of the attack is begun, artillery accompanying this attack very much in the same way as the first. There may be two or more similar stages in the same attack. If fire preparation has been complete, the attack will generally be able to carry the German lines as far as the artillery has been able to batter them, with sufficient efficiency.

The line on which the attack is to stop is to be known beforehand. This must not prevent exploiting the success fully. In case of a big attack this will have been foreseen, and several attacks will have been prepared in succession, followed by a plan of tactical exploitation and strategical exploitation. In this case the objectives of the attack are only to be considered as halting points.

If the aim of the attack is purely local it is nevertheless the duty of everybody to be ready and reap all the profits possible if the success is greater than is expected and if the enemy resistance seems to be crushed. In this case the attack will be carried further than the first proposed objectives, but anyhow the infantry must not cross the line that had been given as definite target without reporting it, and even without orders (if the forward movement is to be important). The order to continue to advance will usually be given only if at least part of the artillery is able to continue its assistance from its positions, while the rest is quickly moving forward.

This line has to be chosen chiefly by taking into account the facilities for barrage, because in the first day or two our infantry will not be in possession of all its means to repulse counter attacks, which will probably be heavy. Artillery barrages must therefore be the chief elements in repulsing these counter attacks. The infantry must therefore remain well within range of our guns (many of which will of course have been pushed as far forward as possible before the attack) and as far as possible stop on a line (either an old German line or not) leaving in front of it at least 200 or 300 meters of open ground easily seen from observing posts not too far from the batteries so that maintaining the communications will be comparatively easy.

If, on the other hand, this line is far enough behind the old German first line to disorganize completely the enemy's observation and communication system, we may be pretty sure that our troops will be able to hold their gains.

As soon as this line is reached (it is known by signalling it back

both directly and through the airplanes that accompany the infantry) the definitive barrage is accurately registered in front of the new position. All 75 batteries (except perhaps a very few engaged on special missions) join in this barrage to make it as thick as possible. The barrage is actually fired at a slowly reducing speed during the first hour or so. After this time, it is fired only if the infantry asks for it, and then at full speed. During the whole following night an officer in each battery will follow closely the changes in weather conditions (as wired from the meteorological post, or this failing, as partly measured [temperature barometer], partly estimated [wind] at the battery) so as to keep the barrage in its proper place.

Some salvos at irregular intervals in front of our new line will help our infantry in entrenching themselves without being worried by snipers. Some batteries will also fire all night on the enemies' communications, where heavy traffic is probably going on (reliefs, troops brought in for counter attacks, artillery moved backwards, etc.). All these night fires are zone fire, prepared accurately from the map (weather conditions being accounted for). Shell with long fuse will be used for most of them.

Some fire with gas shells will also worry the enemy if he prepares for counter attacks or if he reorganizes his defenses. All this time some 75 batteries may have been engaged in conjunction with heavy artillery in counter battery work (chiefly neutralization work with gas shells if weather conditions are suitable).

During this first night, after the attack, part of the field artillery is brought forward in positions either prepared beforehand, or at least fully known, behind our old infantry line or in position summarily reconnoitered in the ground just stormed. New observing posts are also organized and telephone lines laid.

During this time also the infantry organize their first line and working parties begin to link this line to the old ones by communication trenches, using as much of the old enemy system as possible. It is only when a new line is linked by reliable communication trenches to the rear, when barrages are reliable, and when wire entanglements have been laid in front of the first trench, it can only then be said that a line can be securely held. This may take several days. Such a delay is also necessary for moving an important part of the heavy artillery.

It is only when the enemy seems to be enough shaken, by the success of our first attack, that a fresh one may be tried on the next day with only field artillery and long range fire of heavy artillery to support it.

In most cases a complete new preparation by heavy artillery will be necessary and there will be a few days' interval between successive attacks.

(*c*) *After the Attack.*—After the attack the artillery will have to keep careful watch. If they play their part well, enemy counter attacks are bound to fail, and they will find many opportunities to inflict heavy losses upon the enemy.

1. *Barrages* are of the utmost importance, especially in the first few days, when our infantry is still somewhat isolated in their new line, with precarious communication with the rear. There will be no shelter in the first line—to avoid losses, this line will be held by a relatively small garrison. Wire entanglements will not be completed until a few days after the attack. Therefore well adjusted barrages are indispensable. We will see later, when studying a defensive sector, how these barrages are to be established.

2. *Concentration of fire* on the enemy's first line and on his communication trenches (if any) will also prevent him from launching counter attacks.

3. *Concentration of fire* on villages, woods, and so on, when troops are reported or supposed to be massed there, will cause very heavy losses to the enemy, if he really tries to accumulate troops for counter attacks.

4. *Fire on the lines of communication* will also render his task very difficult, especially as the sheltered lines of communication (trenches) may be destroyed and will anyhow be relatively scarce at a rather big distance from his former front line.

5. If the enemy tries to bring up his troops, and to attack in the open, opportunity for all kinds of fire seen, when speaking of open warfare, may be offered. These fires will be very much simplified by the good knowledge of the ground and the accurate maps.

6. Last, but not least, if the advance has been large enough to oblige the enemy to move a considerable part of his artillery, fine opportunities for destroying batteries will be offered because many of them will not yet be protected and some of them may even be only badly camouflaged and will be easily seen if our air service is able to perform its reconnaissance duties.

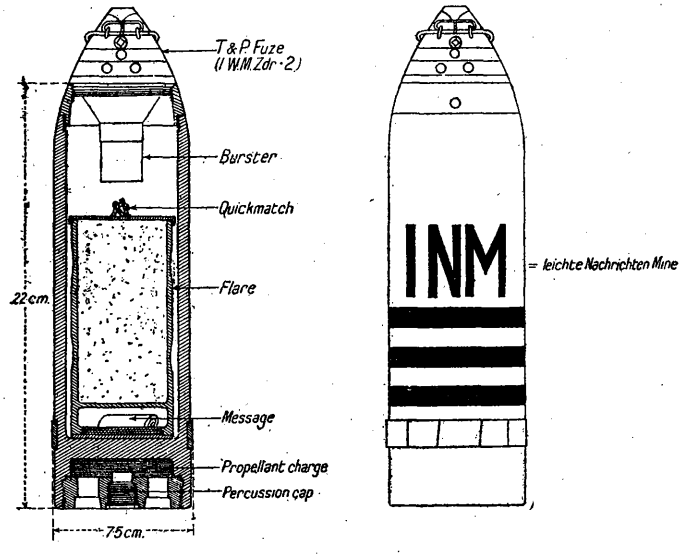
7. Harassing fire directed on all points of the German trenches and lines of communication, by short volleys, chiefly at night, may cause considerable delay in the enemies' work of reorganization, thus giving our own troops time to organize their defense before the enemy is ready to launch systematical counter attacks.

VII.

NOTES ON A

GERMAN MESSAGE SHELL.

Extracts from a Captured Document.



SCALE — $\frac{1}{3}$.

The introduction of the message shell was due to the hope that it would still be possible to send a message in a light *Minenwerfer* shell, when all other means of communication had broken down.

Designation.—Light *Minenwerfer* message shell=*leichte Nachrichten-Mine* (*l.N.M.*).

Maximum range.—1,422 yards. This shell is fired from the (7.6 cm.) new light *Minenwerfer* (1916 pattern).

Distinctive marking.—The letters l.N.M. and 3 black rings round the cylindrical portion.

Description.—The message shell consists of the following parts: A light *Minenwerfer* shell case, a flare in which there is a compartment to take a message, a burster and a time fuse.

Action.—As the shell bursts open in the air, the flare is lighted and so heralds the approach of the message shell. The flare continues to burn for several seconds after the shell has struck the ground. The shell apparently becomes so hot that a pair of pincers is supplied for extracting the flare. The cover of the message compartment has then to be unscrewed with a special key.

Employment.—The message shell provides a means of communication between battalion headquarters and regimental H. Q.'s and from these to the artillery, the brigade or to a report center. For forwarding reports to the division, etc., this system is linked up with the telephone and wireless stations behind the front. At receiving stations, the observer should be posted in a dug-out, with a loop-hole giving on to a well-defined target. This target will have been previously registered. It must be concealed from the enemy, otherwise the receipt of the projectile will be observed and will draw hostile fire. Reports forwarded by this means should always be sent in duplicate by two successive rounds.

VIII.

RECENT ITALIAN NOTES ON COUNTER-BATTERY WORK.

1. The use of high angle fire in counter-battery work is useful but not indispensable; fire with a very flat trajectory with small caliber projectiles is also effective on account of the absence of overhead cover. (105-mm., 102-mm., 75-mm. guns).

2. Time fire might also have been effective for the same reason. This statement naturally applies to the past. This does not mean, however, that conditions may not again be favorable in the future.

3. The good results obtained by counter-battery work in the past offensive lead us to suppose that, by improving the observation service, that is to say, by having the fire on batteries located by aerial photography, and by having batteries located by intersection from terrestrial observation stations, there is great *probability* of demolishing the enemy batteries, and of diminishing the expenditure of ammunition for counter-battery work. Demolition fire should be methodical and *continually observed.*

The amount of ammunition required to demolish a hostile battery, which has been located, that is to say, to put the battery out of action for a certain length of time by damaging the material, reserves, shelters, telephones, etc., may be estimated as follows: 700 to 800 rounds of field artillery ammunition against unprotected artillery, and 500 to 600 rounds of medium caliber ammunition, against slightly protected artillery, according to the range.

4. *Neutralization fire* should be limited to batteries which cannot be located, thus reducing the number of batteries of medium and heavy caliber previously employed and using more field artillery instead. The importance of the defensive works of the enemies, emplacements was *certainly not in proportion* to the enormous expenditure of ammunition and energy on our part during the last offensive, and we may presume that the batteries which we were unable to locate were protected by defilade rather than by overhead cover.

5. The fact that the majority of hostile batteries, which could not be located, were situated in caves and similar places, proves that a great deal can be obtained by a rational and well-organized use of special projectiles.